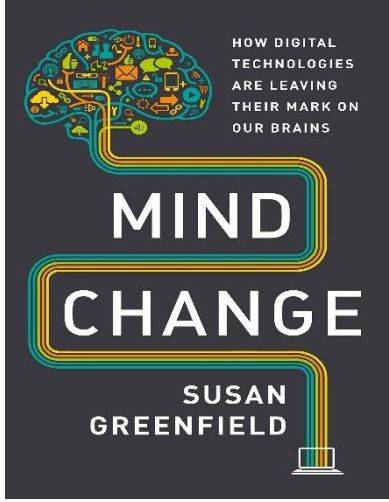
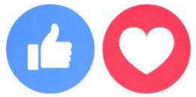


Use of technology and networking:

how do they change our brain

Conceptual map

1) Share information → we have different selves →privacy??

2) 

3) 

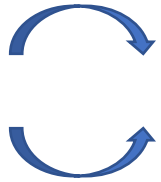
4) 

IDENTITY and SOCIAL RELATIONSHIP

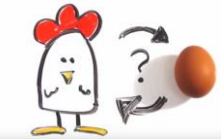
Change of the world

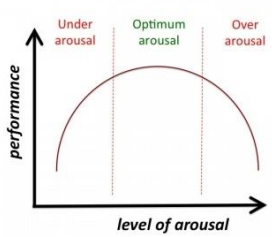
Change of the brain

FREE TIME



enlarged ventral striatum





AGGRESSION

LEARNING

1) Memory →google effect

Google

2) Searching

3) Reading

4) Multitasking

Summary

- **Change of the World: from 3D to 2D**
- How our brain works and changes
- Effects of the digital world on identity and relationship
- Effects of the digital world on free time and aggressivity
- Effects of the digital world on memory and learning

Change of the World: from 3D to 2D

3D world

PC

Smartphone

TV

Tablet

Change of the World: from 3D to 2D

3D world

PC

Smartphone

TV

Tablet

- Tech is everywhere
- Facts can be accessed at random
- Actions can be reverse
- Time is short
- 24/7 responsive and productivity

Change of the World: from 3D to 2D

This change seems different from previous changes (car, electricity, TV) for different reasons:

1) This change is different of its pervasiveness.

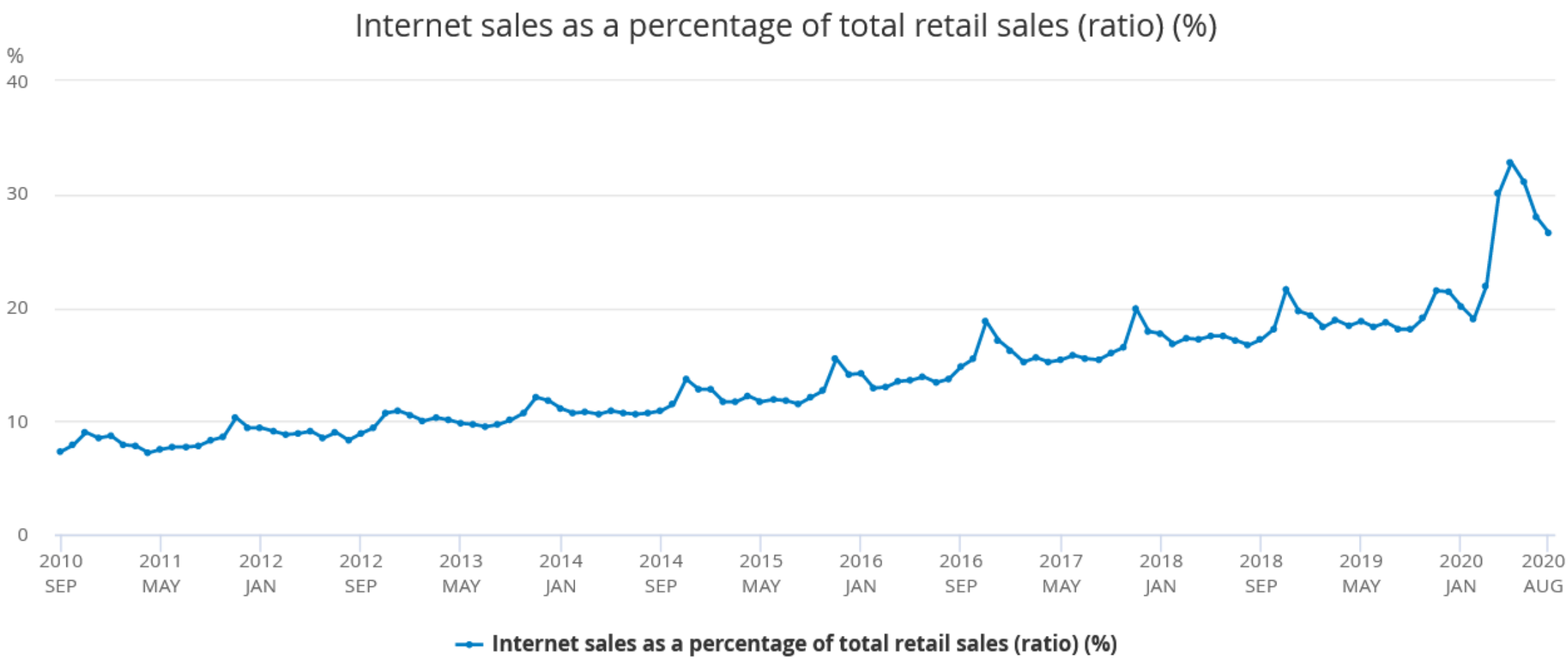
2) The shift from technology as a means to its being an end in and of itself

Pervasiveness

- In **2011**, 71 percent of adult U.S. Internet users bought goods online, and the following year a comparable number, 87 percent, of U.K. adults ages twenty-five to forty-four were **shopping online**.
- By **2017**, online sales are projected to account for 10 percent of all retail sales in the United States.
- U.S. Internet users spend 22.5 percent of their **online time** on **social networking** sites or blogs.
- More than a third of couples who married between 2005 and 2012 in the United States reported **meeting their spouse** online, with about half of these meeting through online dating sites and the rest through other online sites such as social networking sites and virtual worlds.

Prensky, M. (2001); Keen, A. (2007); Selwyn, N. (2009); KidScape. (2011).

Internet sales as a percentage of total retail sales (ratio) (%)



www.ons.gov.uk

Pervasiveness

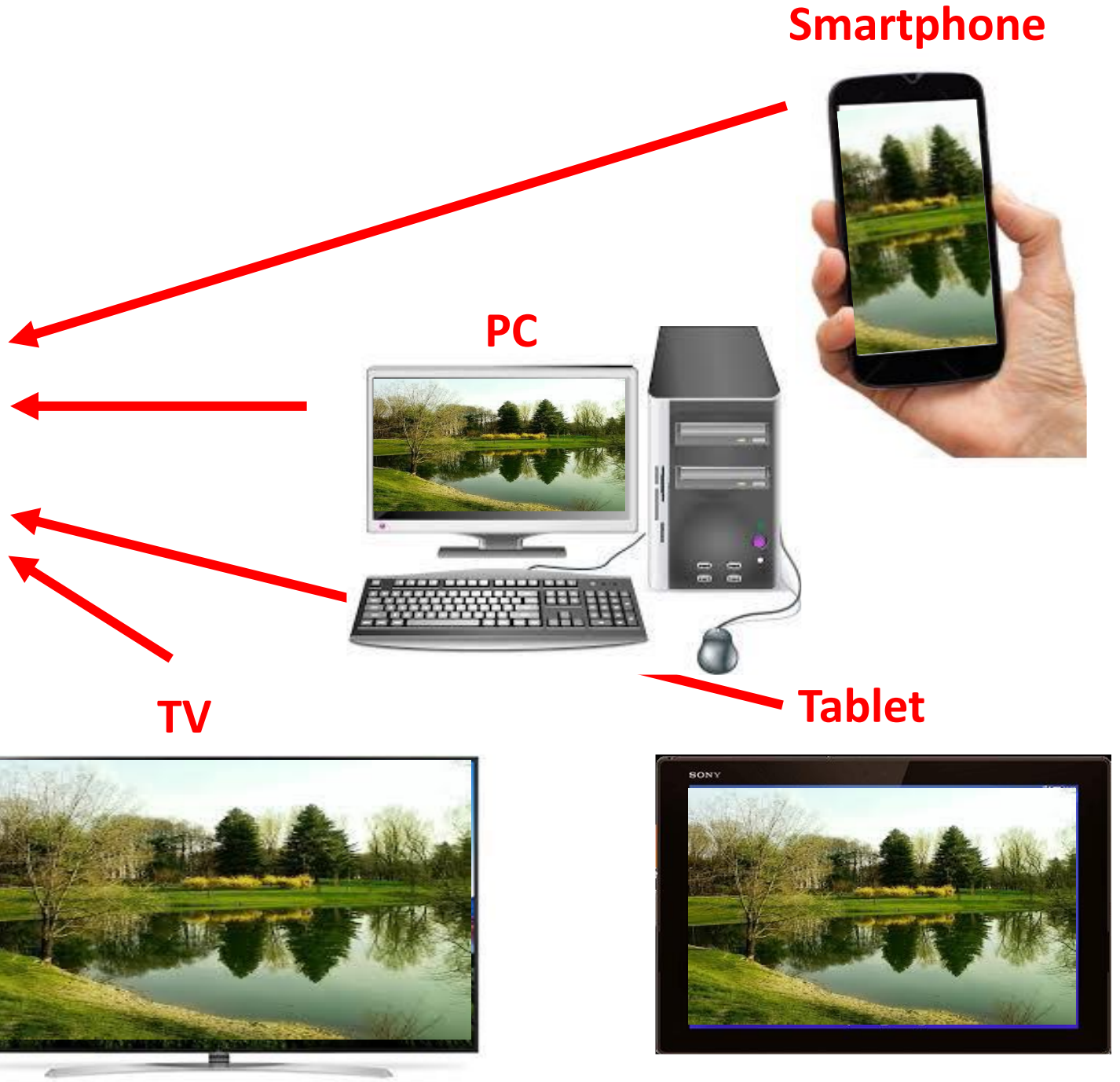
- Study on US adults using social networking sites

- 24% of U.S. adult users of social networking sites reported a curious phenomenon in **2012**—that they missed out on a key event or moment in their lives because they were so absorbed in updating their social networking site about that event or moment.

Badoo. (2012).

Pervasiveness

- Work/study
- Communicate with friends
- Find new friends
- Gain information and news
- Shopping
- Spare time
- Alarm
- Maps
- …



Pervasiveness for who?

3D world

2D world

Different GENERATIONS

Digital Native vs Digital Immigrants

- **Digital Native**: “someone defined by his or her perceived outlook and abilities, based on an **automatic** facility and familiarity with digital technologies”

- **Digital Immigrants**: “have adopted many aspects of the technology, but just like those who learn another language later in life, retain an ‘accent’ because we still have one foot in the past”

Prensky, 2001.

Digital Native vs Digital Immigrants

- **Digital Native**: the date of birth of the Digital Native seems therefore to be uncertain
  - ✓back as the 1960s when the term “computer” entered into common language
  - ✓late 1990 when emails became reality

- **Digital Immigrants**: “have adopted many aspects of the technology, but just like those who learn another language later in life, retain an ‘accent’ because we still have one foot in the past”

Prensky, 2001.

Digital Native vs Digital Immigrants

The former are still learning the enormous potential of these technologies in adulthood, while the latter have known nothing else

Irrespective of the date of born, parents are most likely to be Digital Immigrants and their children Digital Natives

Summary

- Change of the World: from 3D to 2D
- **How our brain works and changes**
- Effects of the digital world on identity and relationship
- Effects of the digital world on free time and aggressivity
- Effects of the digital world on memory and learning

Brain Changes

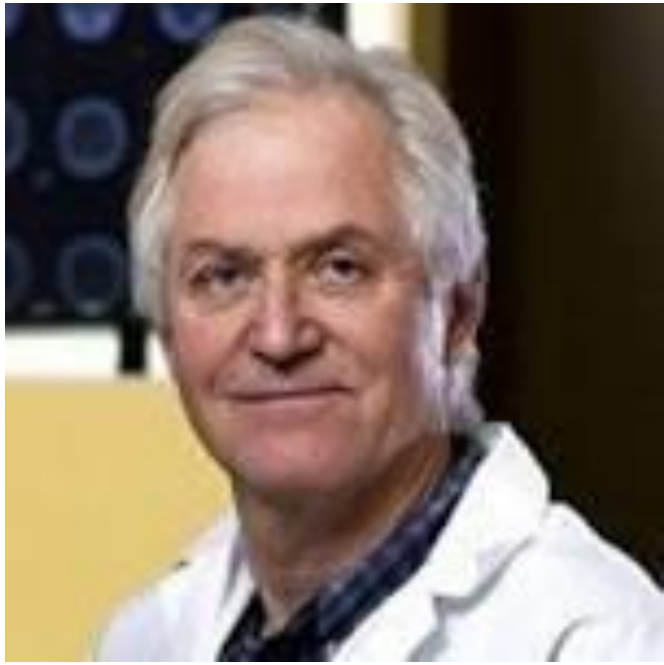
3D world

human brain will adapt to whatever environment in which it is placed

2D world

≠

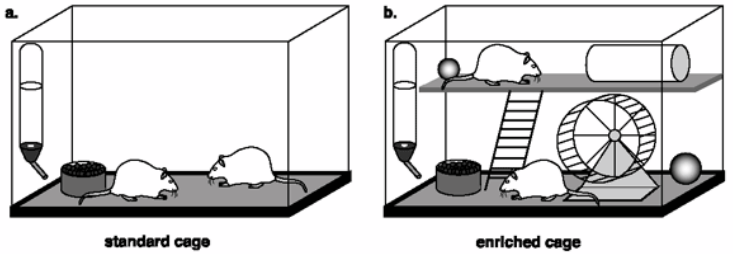
Brain Changes



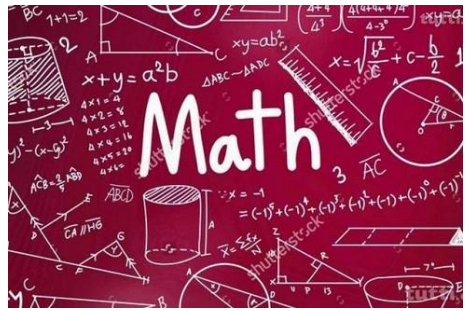
One leading expert in brain development, Bryan Kolb, sums up: "*Anything that changes your brain, changes who you will be. Your brain is produced not just by your genes; it's sculpted by a lifetime of experiences. Experience alters brain activity, which changes gene expression. Any behavioral changes you see reflect alterations in the brain. The opposite is also true: behavior can change the brain*."

Kolb, B. (2009).

Brain Changes



Let's see **examples** of this brain **plasticity**:



Kolb, B. (2009).

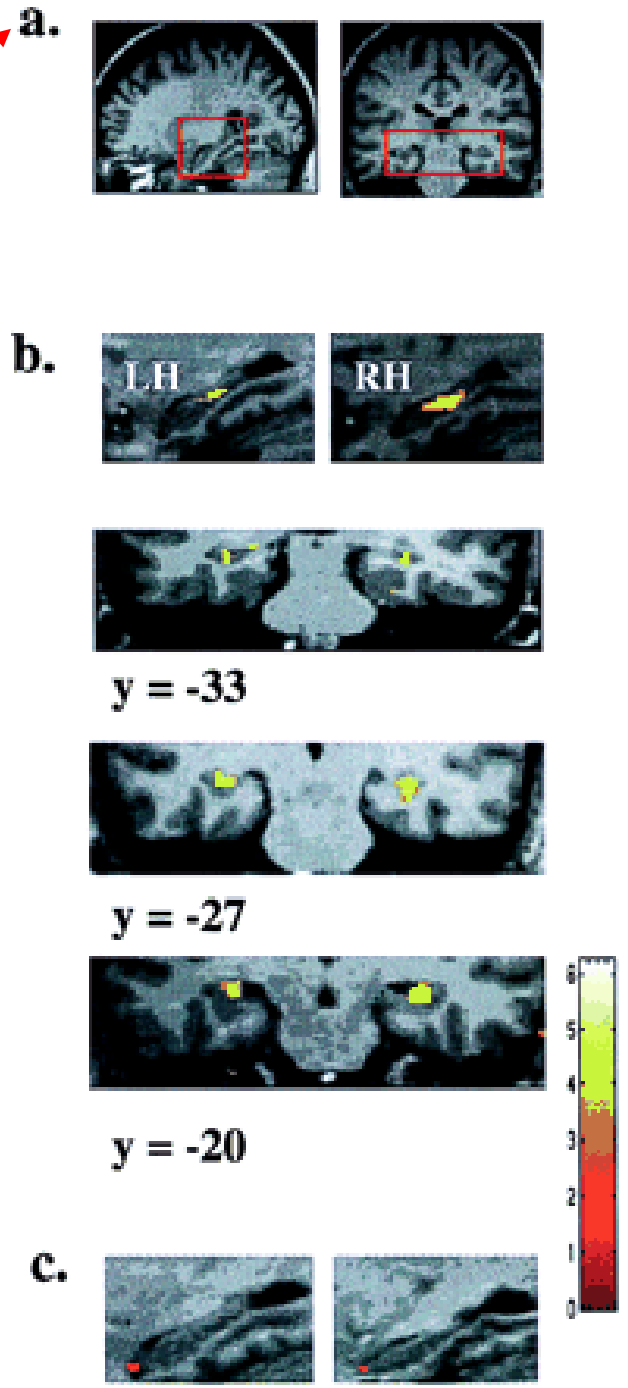
London taxi drivers

For a rookie driver → 2y after passing “the Knowledge” to become a good taxi driver!

Do London Taxi Drivers show physical changes in their brains as a result of the very daily use of their working memory?

Maguire et al (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences* 97, no. 8, 4398–4403.

London taxi drivers

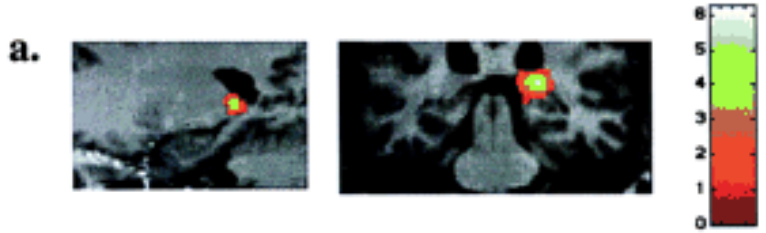


Sagittal section of an MRI scan with the **hippocampus** indicated by the red box. (*a Right*) Coronal section through the MRI scan, again with the hippocampi indicated. (*b*) The group results are shown superimposed onto the scan of an individual subject selected at random. **The bar to the right indicates the *Z* score level**.

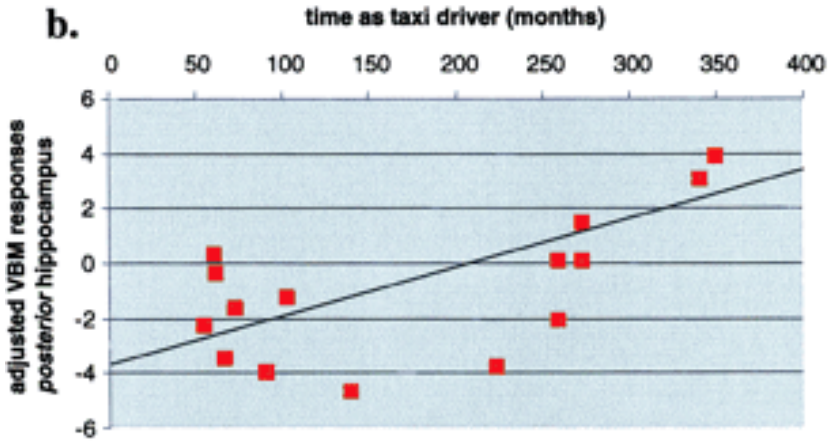
Increased gray matter volume in the posterior of the left and right hippocampi (LH and RH, respectively) of taxi drivers relative to those of controls, shown in the top of the figure in sagittal section.

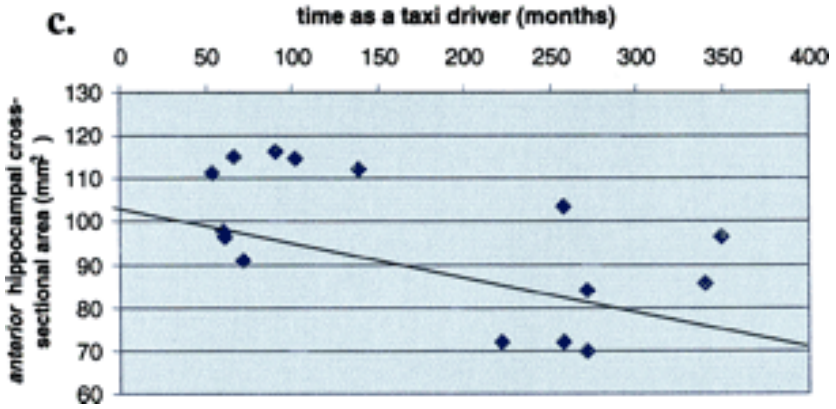
Maguire et al (2000)

London taxi drivers



Correlation of volume change with time as a taxi driver. (*a Left*) Sagittal section. (*a Right*) Coronal section. The voxel-based morphometry group results are shown superimposed onto the scan of an individual subject selected at random. The bar to the right indicates the *Z* score level.
The volume of gray matter in the right hippocampus was found to correlate significantly with the amount of time spent learning to be and practicing as a licensed London taxi driver, **positively in the right posterior hippocampus** (*b*) and negatively in the anterior hippocampus (*c*).





Maguire et al (2000)

Training dogs and birds

- Changes in the brain as a result of experience were actually first shown as long ago as 1783 by the Swiss naturalist Charles Bonnet and the Michele Vincenzo Malacarne

- They discovered that **training dogs and birds led to an increase in the number of folds in a part of the brain** (the cerebellum), compared to dog littermates or birds from the same clutch of eggs

Doidge N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science.* New York: Penguin, p. 315.

Visual Plasticity

- In the first years of life the brain has **windows of opportunity**, characterized by the exuberant growth of connections between neurons, which allows for astonishing possibilities.
- E.g. in infants the **visual** and **auditory compartments** of the cortex appear to be **functionally interchangeable**, equally effectively stimulated by either hearing or vision.
- Consequently, when there is a **loss** of vision in early childhood, some form of hearing ends up sharper through a process known as cortical **remapping**. Because the visual sector is not being used for its normal job, it adapts to whatever inputs are available and takes on an alternative role, helping the brain process hearing with a resulting greater prowess.

Bavelier and Neville (2002). Cross-modal plasticity: Where and how? *Nature Reviews Neuroscience* 3, no. 6, 443–452. doi:10:1038/nrn848.

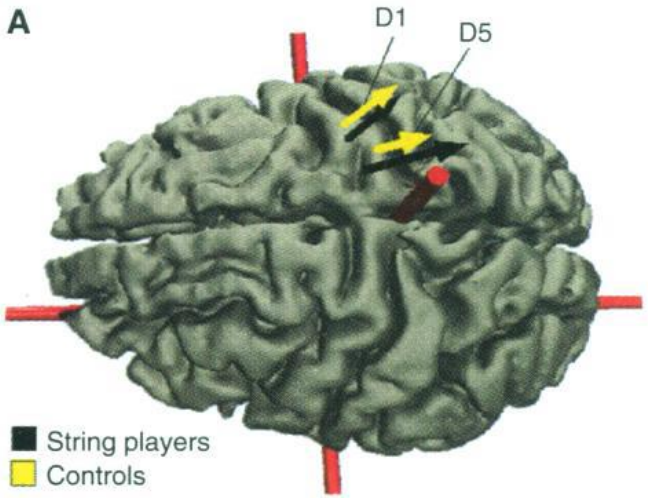
Musicians

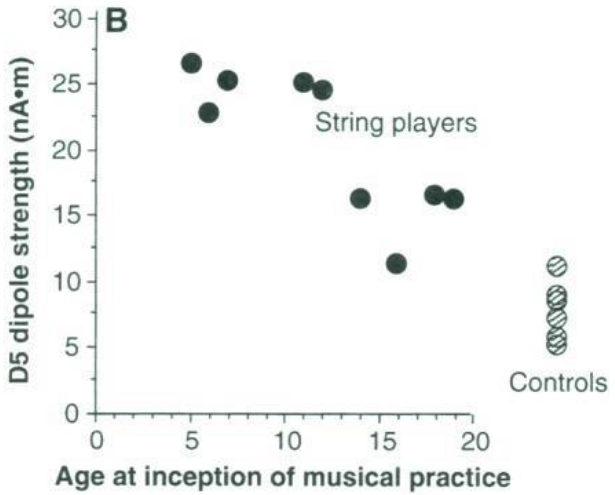
- Musicians who play string instruments exercise their left hands more than their right and, in these players, the section of cortex related to touch is accordingly larger for the left hand than the right (right cortex, left hand).

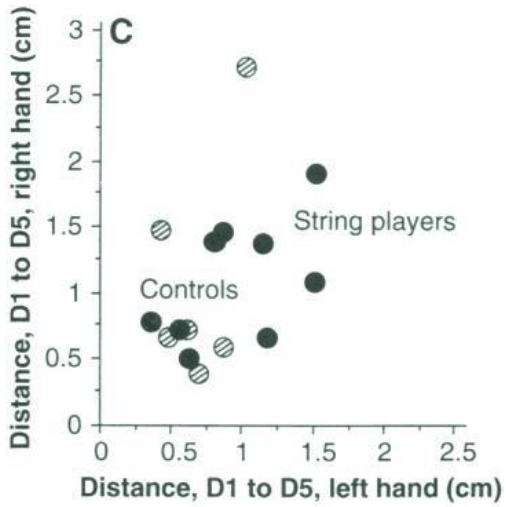
- Study design:
  - Nine musicians (six violinists, two cellists, and one guitarist) who had played their instruments for a mean period of 11.7 years (range, 7 to 17 years) served as subjects for this study.
  - Six non-musicians served as controls.
  - During the experimental session, somatosensory stimulation was delivered to the first digit and, in separate runs, to the fifth digit of either hand.

Elbert et al., (1995). Increased cortical representation of the fingers of the left hand in string players. *Science* 270, no. 5234, 305–307.

Musicians







The section of cortex related to touch is accordingly larger for the left hand than the right.

The data indicate that the center of cortical responsivity for tactile stimulation of the digits of the left hand was shifted in musicians as compared to that in controls.

Elbert et al., (1995). Increased cortical representation of the fingers of the left hand in string players. *Science* 270, no. 5234, 305–307.

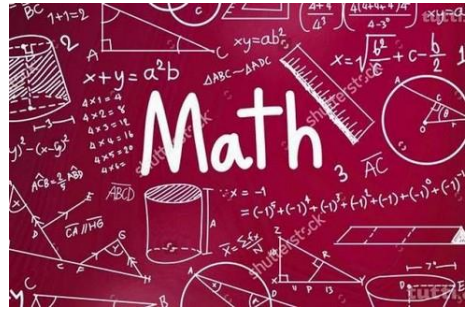
Musicians

- Anatomical scans of **professional musicians** (keyboard players), **amateur musicians**, and **nonmusicians** showed size differences in a range of structures: motor, auditory, and visuo-spatial brain regions

- It's worth noting that there are strong relationships between **musician status and practice intensity**, suggesting the anatomical differences are linked to learning and not to a predisposition to music.

Gaser, C., and Schlaug, G. (2003). Brain structures differ between musicians and non-musicians. *Journal of Neuroscience* 23, no. 27, 9240–9245.

Training in Math



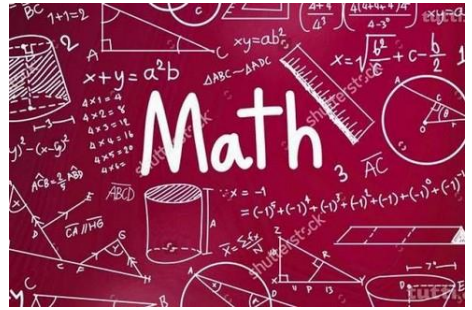
- Normal human subjects with no particular skill or talent are trained from scratch in some standardized experimental tasks

- The training to acquire or practicing to perform a skill, which may lead to structural changes in the brain, is called **experience-dependent structural plasticity**.

- The main purpose of this cross-sectional study was to investigate the presence of experience-dependent structural plasticity in **mathematicians' brains**

Aydin, K et al., (2007). Increased gray matter density in the parietal cortex of mathematicians: A voxel-based morphometry study. *American Journal of Neuroradiology* 28, no. 10, 1859–1864.

Training in Math



- Twenty-six volunteer mathematicians, who have been working as academicians, were enrolled in the study

- Authors assessed the **gray and white matter density** differences in mathematicians and the control subjects. Moreover, the correlation between the cortical density and the time spent as an academician was investigated.

Aydin, K et al., (2007). Increased gray matter density in the parietal cortex of mathematicians: A voxel-based morphometry study. *American Journal of Neuroradiology* 28, no. 10, 1859–1864.

Training in Math

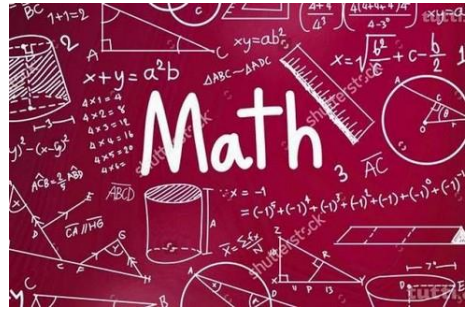
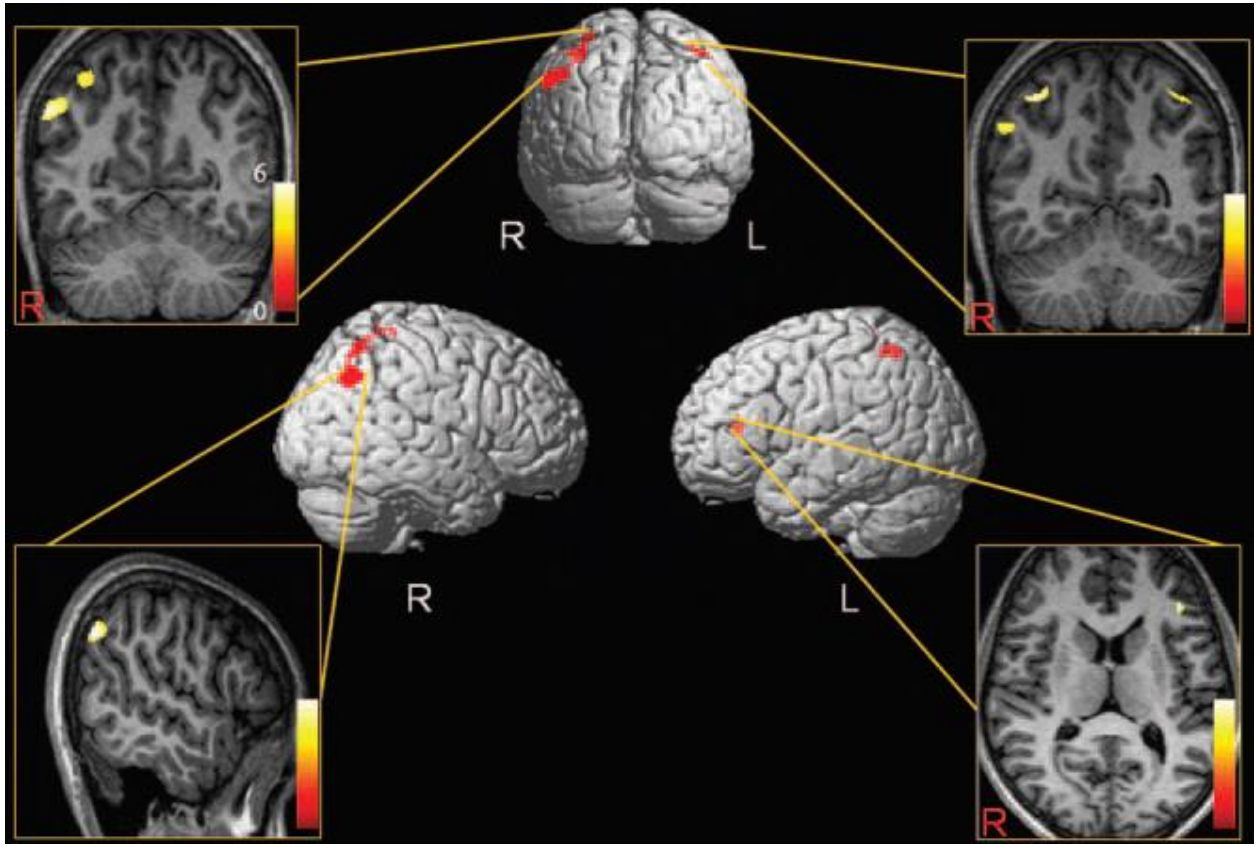


Fig 2. *A*, The result of the regression analysis testing the **correlation between gray matter density of the mathematicians and period of time spent as an academician** is overlayed on the normalized T1-weighted images.

They show that **gray matter density in the right inferior parietal region** (Talaraich coordinates: x 57, y60, z 34) of the mathematicians **is strongly correlated with the duration of time spent as an academician** (*z* 7.28; *P* .05, FWE corrected).



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Training in Math

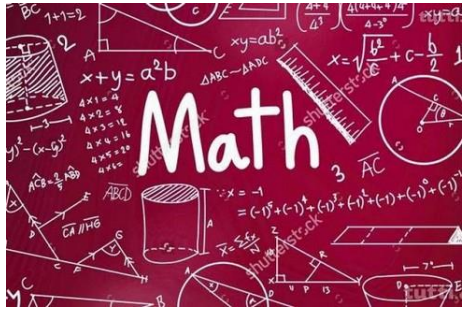
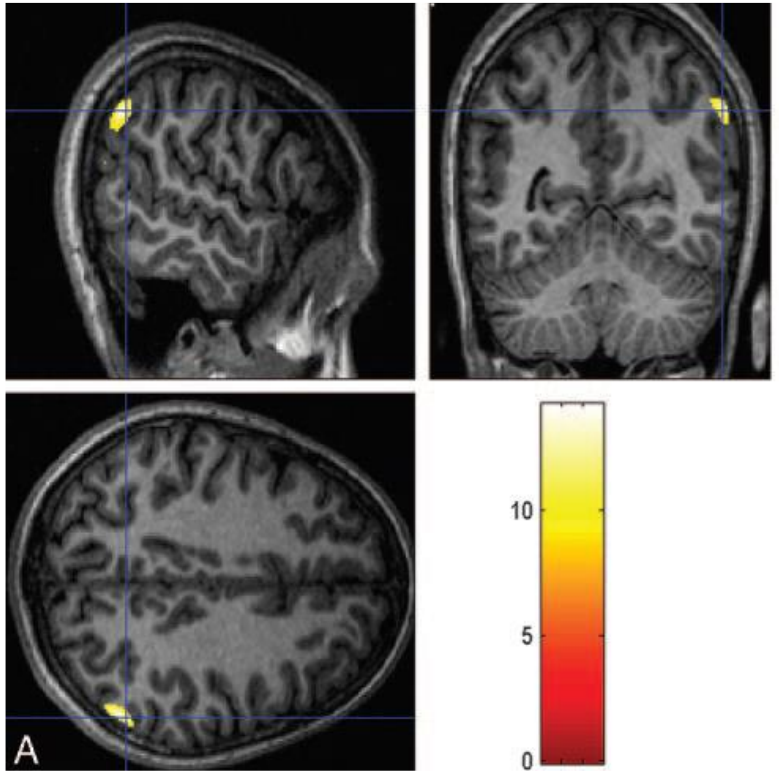
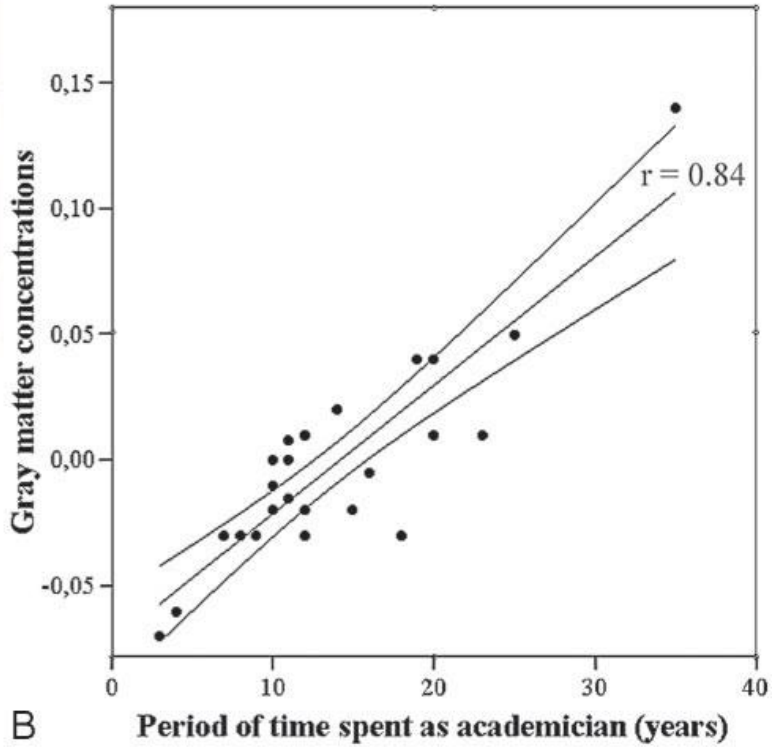


Fig 2 *B*, The gray matter density values from the voxels showing the maximum correlation on the statistical parametric mapping regression analysis are extracted into SPSS. The scatter-plot graph shows **the linear regression between the gray matter density and the duration of time spent as an academician** (*r* 0.84; *P* .01). The *middle line* represents the linear regression, and the *curves* around it represent the 95% confidence intervals.





Aydin, K et al., (2007). Increased gray matter density in the parietal cortex of mathematicians: A voxel-based morphometry study. *American Journal of Neuroradiology* 28, no. 10, 1859–1864.

Training in juggling

- Subjects underwent **daily training for three months** to learn a three-ball juggling task, where perception and anticipation were key to determining upcoming movements accurately.
- Scans were performed **before** training, after **three months** of **training**, and then after **another three months** in which **no juggling** was attempted, by which time performance had deteriorated back to baseline: use it or you will lose it.

- Changes in gray matter after training.

Draganski et al., (2004). Neuroplasticity: Changes in gray matter induced by training. *Nature 427, no. 6972, 311–312.*
Driemeyer et al., (2008). Changes in gray matter induced by learning: Revisited. PLOS ONE 3, no. 7, e2669.

Training in juggling

- Scans before training → no significant regional differences in grey matter between jugglers and non-jugglers
- Scans after training → the juggler group demonstrated a bilateral expansion in grey matter in the mid-temporal area and in the left posterior intraparietal sulcus
- This expansion decreased in the third scan

→learning-induced cortical plasticity is also reflected at a structural level

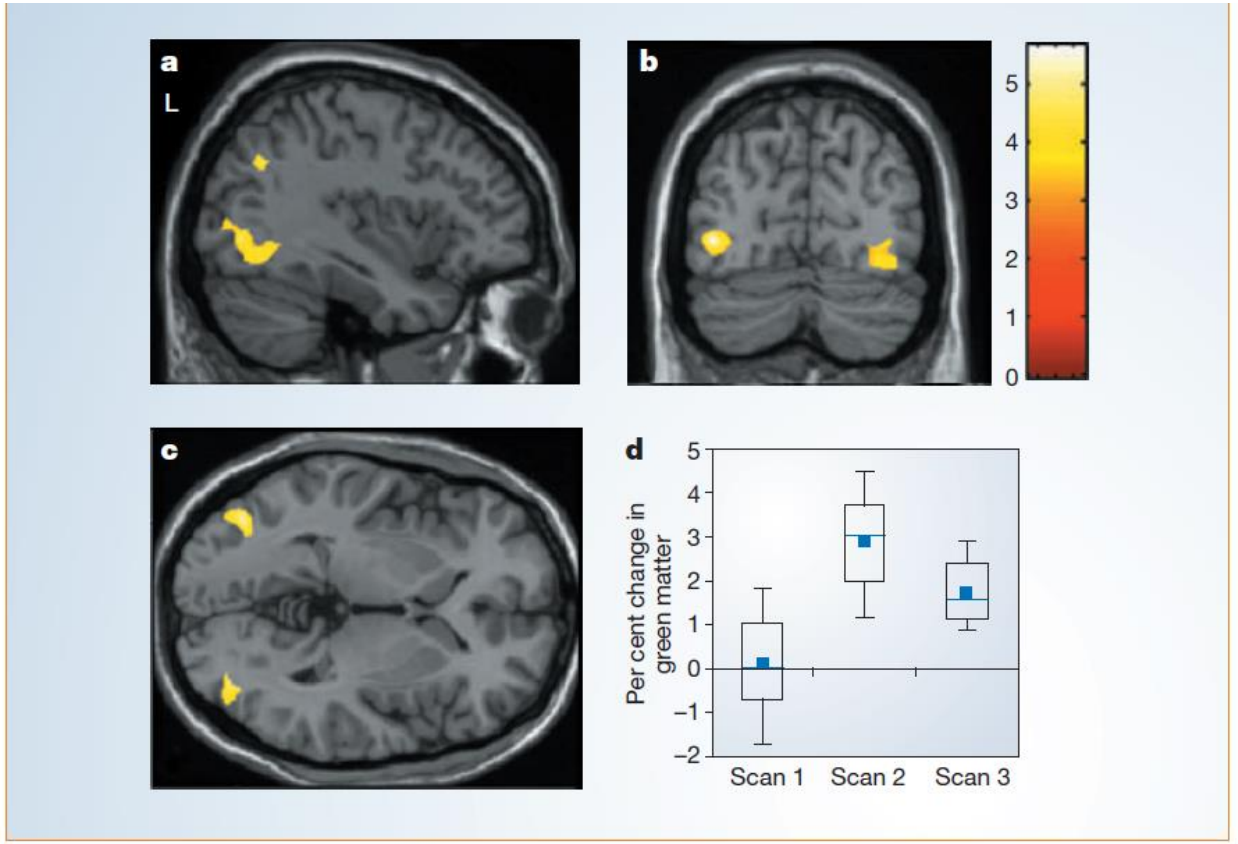
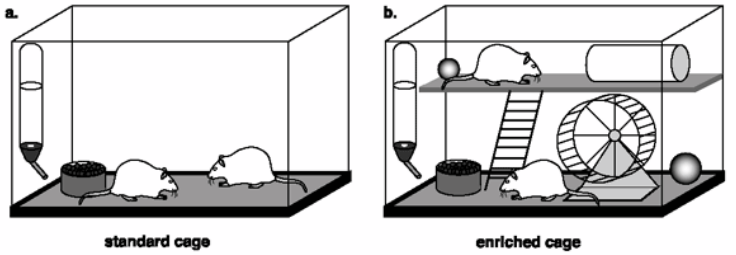


Figure 1 Transient changes in brain structure induced while learning to juggle. **a–c,** Statistical parametric maps showing the areas with transient structural changes in grey matter for the jugglers group compared with non-juggler controls. **a,** Sagittal view; **b,** coronal view; **c,** axial view. The increase in grey matter is shown superimposed on a normalized T1 image. The left side (L) of the brain is indicated. A significant expansion in grey matter was found between the first and second scans in the mid-temporal area (hMT/V5) bilaterally (left: *x*, –43; *y*, –75; *z*, –2, with $Z = 4.70$; right: *x*, 33; *y*, –82; *z*, –4, with $Z = 4.09$) and in the left posterior intraparietal sulcus (*x*, –40; *y*, –66; *z*, 43 with $Z = 4.57$), which had decreased by the time of the third scan. Colour scale indicates *Z* scores, which correlate with the significance of the change. **d,** Relative grey-matter change in the peak voxel in the left hMT for all jugglers over the three time points. The

Draganski et al., (2004). Neuroplasticity: Changes in gray matter induced by training. *Nature 427, no. 6972, 311–312.*

Driemeyer et al., (2008). Changes in gray matter induced by learning: Revisited. PLOS ONE 3, no. 7, e2669.

Studies of enriched environments

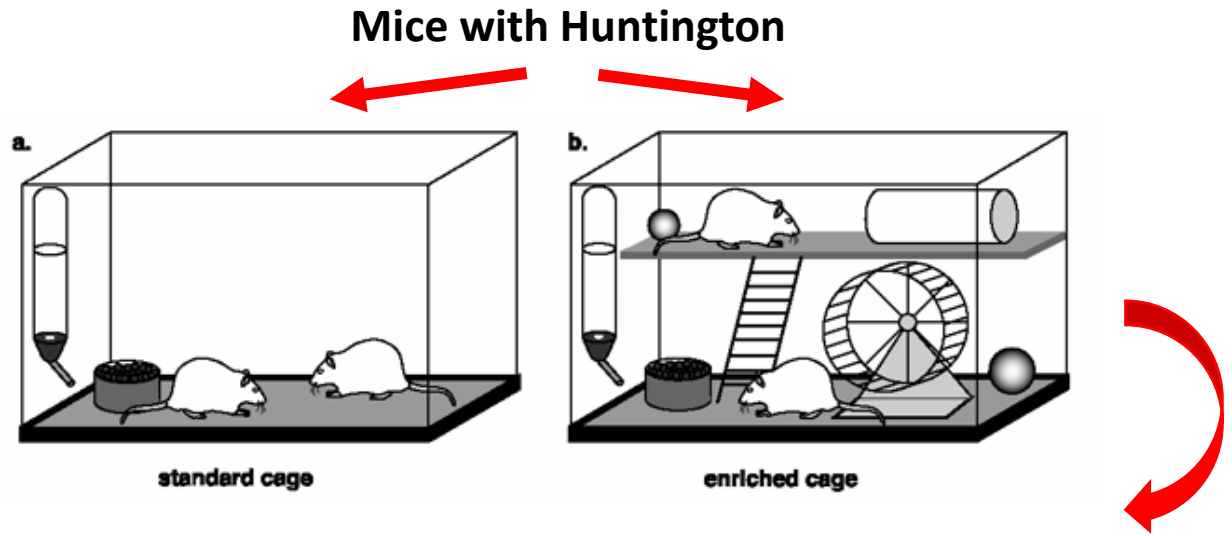


- The earliest demonstration of the impact of the outside world was with what was eventually to be called an “enriched” environment and dates back to the 1940s

- Hebb took some of his lab rats home!! Home rats → superior problem solving compared to Lab rats.

- Mark Rosenzweig and his team at the University of California in 1964, mentioned for the first time the term “environmental enrichment”- They demonstrated for the first time physical changes in neural circuits through experience

Studies of enriched environments

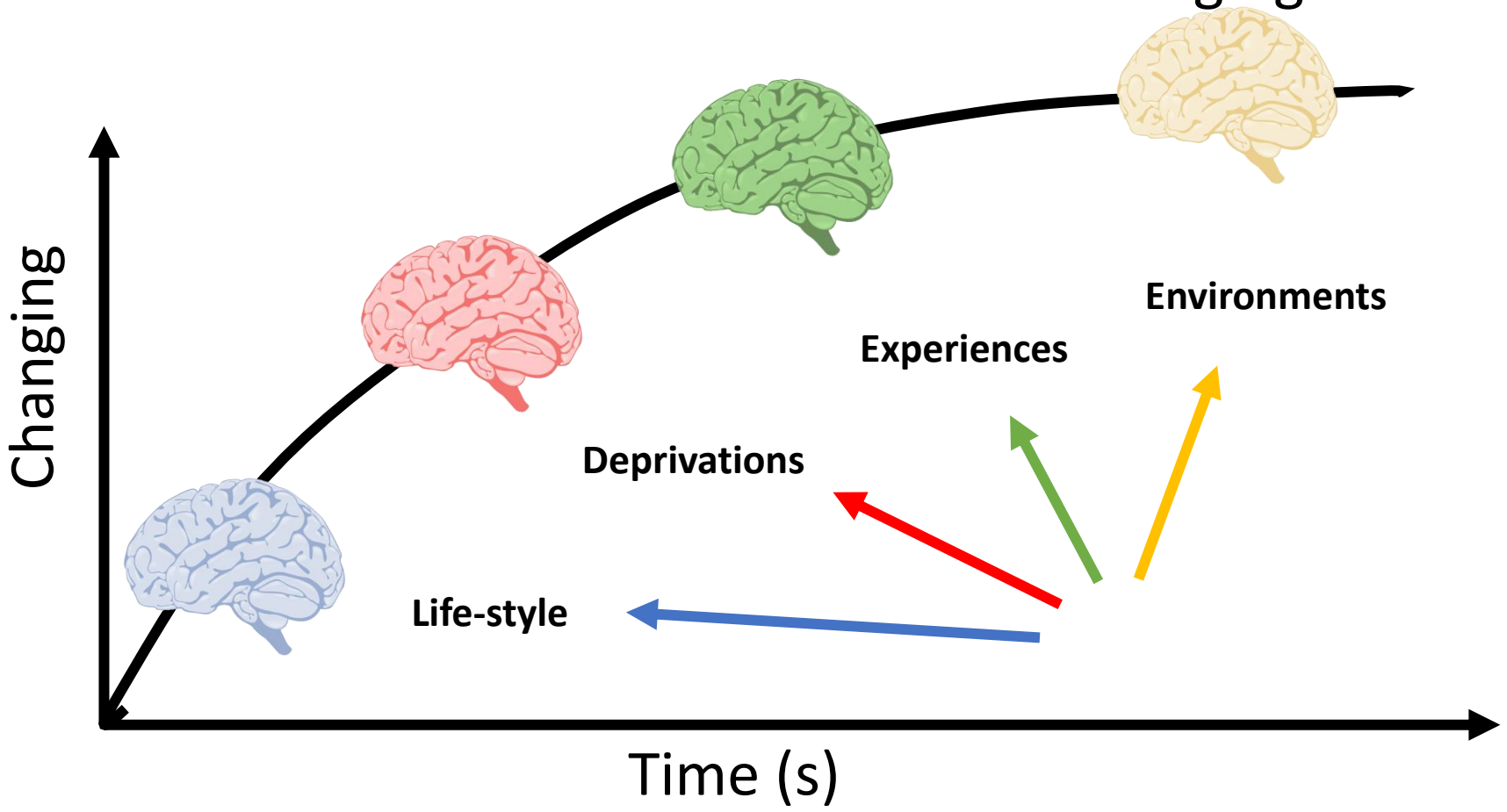


The study conclusively demonstrated that **mice living in such a stimulating environment** developed movement problems much later and with a far more modest degree of impairment. Even here, with a disorder linked to a single gene and in the less complex brains of mice, nature and nurture interact.

Van Dellen, A., Blakemore, C., Deacon, R., York, D., and Hannan, A. J. (2000). Delaying the onset of Huntington's in mice. *Nature* 404, no. 6779, 721–722. doi:10:1038/35008142.

Conclusions

- Our brain is active and can change throughout our lifetime
- Different factors can contribute to these changings



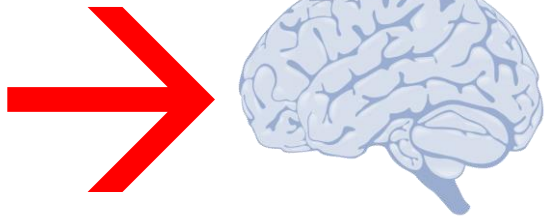
Brain Changes

Considering the abovementioned evidences, it is clear that a decreased exposure to 3D world, along with a more exposure to a 2D worlds, will change our brain

3D world

<

2D world



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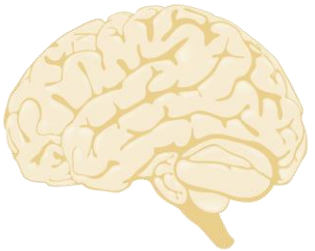


What do we do online?

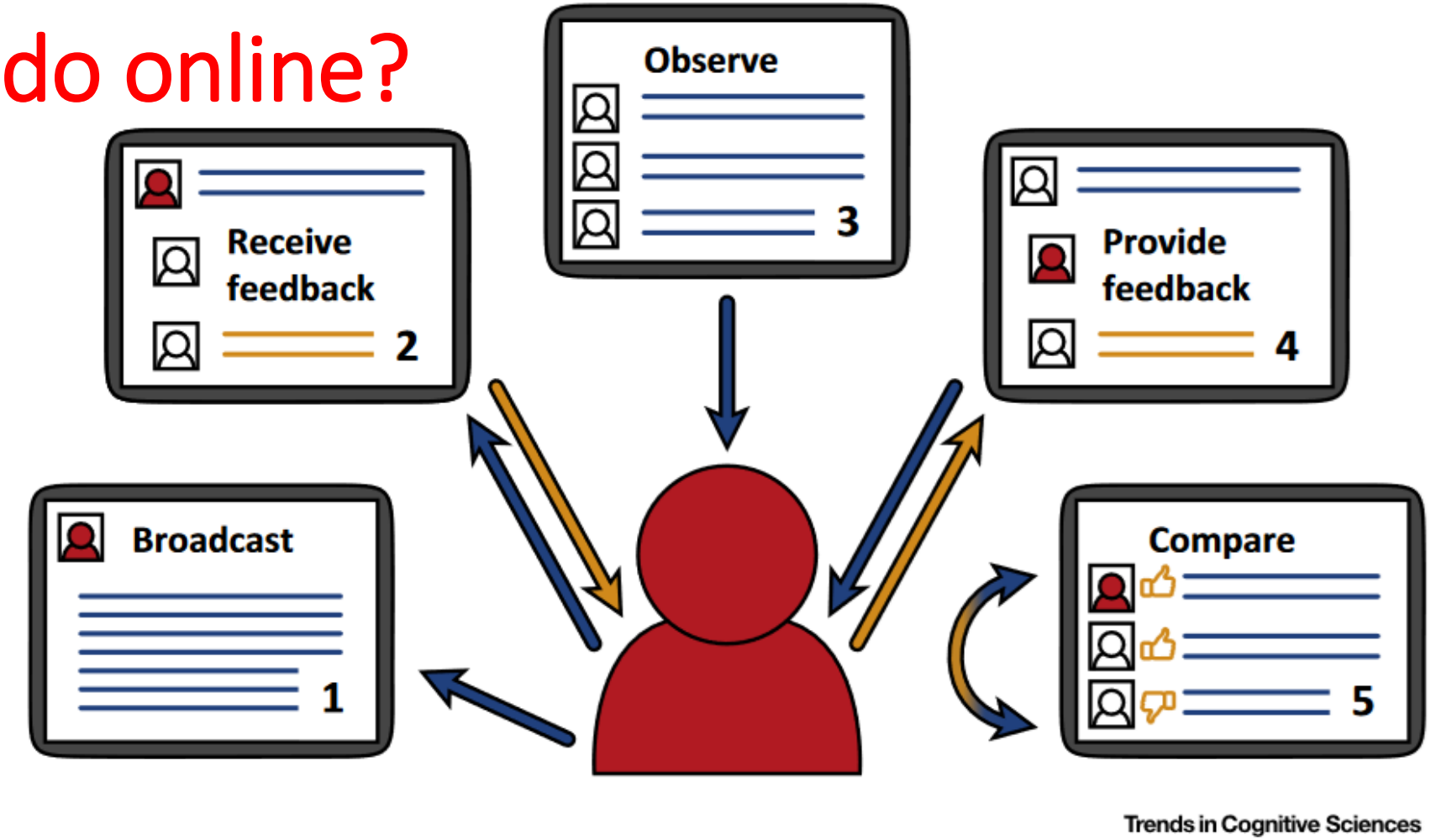


Figure 1. Five Key Social Media Behaviors. Social media users can: (1) broadcast information; (2) receive feedback on this information; (3) observe the broadcasts of others; (4) provide feedback on the broadcasts of others; and (5) compare themselves with others.

Meshi et al., (2015). The Emerging Neuroscience of Social Media. *Trends in Cognitive Sciences, Vol.19, No.12 771-782. http://dx.doi.org/10.1016/j.tics.2015.09.004*

What do we do online? Which are the consequences?

Online activities

- Share information
- Add comments
- Interact with “friends”

Biological and psychological consequences

- 1. Change of the concept of identity
  2. Change of the concept of privacy
  3. Cerebral changes after sharing
- 4. “Like” effect and “dopamine” effect
- 5. Seeking attention and positive feedbacks
  6. Change of friends
  7. Change of communication style
  8. Facebook stress

Summary

- Change of the World: from 3D to 2D
- How our brain works and changes
- **Effects of the digital world on identity and relationship**
- Effects of the digital world on free time and aggressivity
- Effects of the digital world on memory and learning

What do we do online? Which are the consequences?

Online activities

- Share information

Biological and psychological consequences

1. Change of the concept of identity
2. Change of the concept of privacy
3. Cerebral changes after sharing

We share…

- Personal information (true or false)
- We share our identity (real, virtual or desired)

Previous researches on online ID:

1) Focus on the lack of identity →role of anonymity
2) Focus on the possibility to change online ID and on the quality of information shared

Different "Selves"

Based on different psychological theories and studies on self, we can argue that we have not only one self but different selves, used in different conditions and contexts

True Self: notion introduced by Carl Rogers (1951). The true self is based on existing characteristics that need not necessarily be fully expressed in normal social life, perhaps because there are not necessarily occasions when they'll be manifest; rather, they are imagined as particular reactions in hypothetical situations.

The picture of Dorian Gray

Real (life) self: the conformed individual who is constrained by social norms in face-to-face interactions

True Self on Internet: concept developed by John Bargh and coworkers (2001). It refers to an individual's tendency to express the "real" aspects of the self through anonymous Internet communication rather than face-to-face communication. The idea is that the Internet provides individuals with a unique opportunity for self-expression that encourages people to reveal their true self.

Different “Selves”

- Social networking has now resulted in a new self: **the hoped-for**, **possible self** displayed on social networking sites.

- Individual's **possible selves** are thought to be the cognitive link between past experiences and future **hopes**, desires, fears, and fantasies.
- They represent what we **hope** to become as well as what we **hope** to avoid becoming; we call these **hoped** for and feared **selves**, respectively.

Zhao, Grasmuck, and Martin, 2008.

Which self do you share?

Kidscape, a British charity that helps prevent bullying and protects children, conducted a survey in which they assessed young people's cyberlives through an online questionnaire.

- N=230
- Age: 11-18 (from England, Scotland, and Wales)
- Results: one in two (50%) say they **lie** about their personal details on the Internet.
- Results: the one in eight young people who speak to strangers online are the most likely not to tell the truth, with 60% lying about their age and 40 % about their personal relationships
- Results: that young people start to change their identities and to act differently online at just eleven years of age; create identities that allow them to be more rude, more sexy, more adventurous; and generally indulge in inappropriate behavior

KidScape. (2011). *Young people's cyber life survey*.

Sharing effect

N = 35

Age: 19-34 years

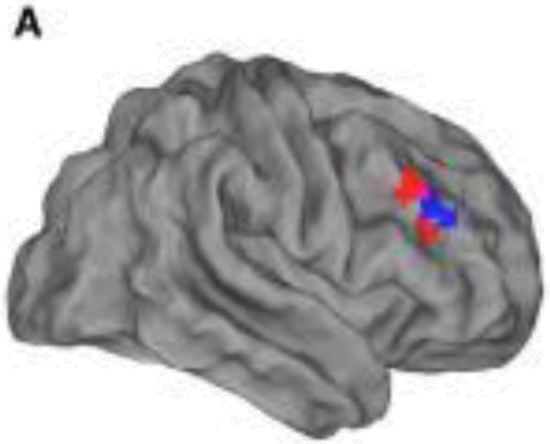
Aim: investigated the intrinsic functional organization of the brain with respect to participants' degree of self-related information sharing

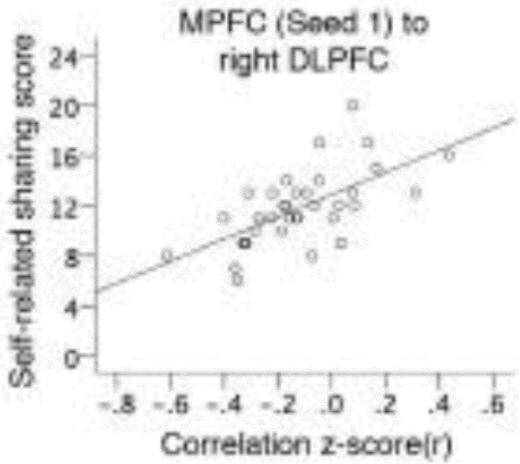
Methods:

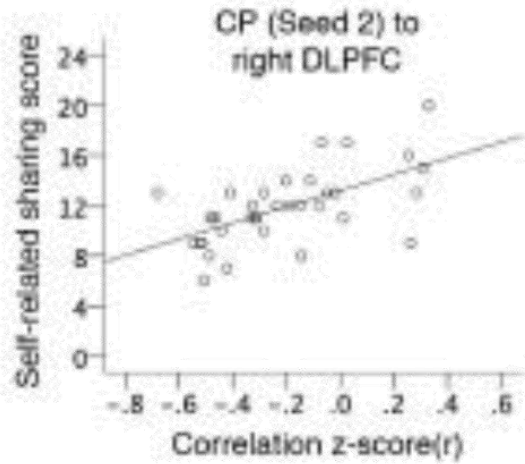
- resting state functional magnetic resonance imaging
- self-reported social media use →Participants were given a survey to assess the degree that they share self-related information, both written and visual, on Facebook

Meshi et al., Scientific Report, 2016

Sharing effect







ROI:

1) **Medial prefrontal cortex (MPFC)** → crucial role in decisional processes and consolidation of long term memory
2) **Central precuneus (CP) (medio-parietal region)** →episodic memory, visuo-spatial imagination, consciousness, self-thinking and meditation
3) **Dorsolateral prefrontal cortex (DLPFC)** →executive functions (planification, reasoning, problem solving)

RESULTS:

Connectivity of both the MPFC and CP, but not connectivity of the cACC, **to other brain regions** is **associated with the degree of self-related sharing**

→the higher the connectivity the higher the degree of self-related sharing

Meshi et al., Scientific Report, 2016

Need to share, need to be approved

- Attention and approval from adults are among the strongest rewards we experience as we are growing up.
- Infants need a meaningful relationship with a caring and involved adult in order to survive and grow. Astonishingly, human growth hormone is thought to be released in proportion to the amount of caring attention a child receives.
- When we aren’t met with positive feedback, we no longer feel safe and protected. And over time we become conditioned to crave approval not just from our parents but from others as well

Need to share, need to be approved…

- The importance of such recognition does not diminish with age. Unlike the real world, Twitter and Facebook can always be relied on to provide an almost instant response to even your adult demands for attention.

- This in turn may explain why the obsessive social networker relies on the illusion of cyber-intimacy, despite the inevitable price of a loss of **privacy**.

…despite the loss of privacy

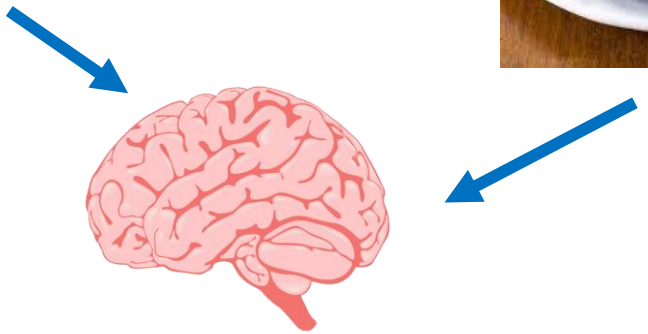
- Many of us take privacy for granted until we feel it is being invaded
- Privacy appears to be a less prized commodity among the younger generation of Digital Natives: nearly half of teenagers have given out personal information to someone they don't know, including photos and physical descriptions.
- Meanwhile, over half of young people send out group messages to more than 510 "friends" at a time (the number of Facebook friends an average youth has),42 fully aware that each of these contacts could then pass on that information to their network of hundreds more

McAfee. (2010). *The secret online lives of teens*.
Arbitron and Edison Research. (April 2013). *The infinite dial 2013: Navigating digital platforms*.

Sharing effect

- As a species, we seem to have such a craving for self-disclosure that it could be considered a very basic part of the human psyche

- Harvard scientists have actually demonstrated that **sharing personal information** about oneself, as on social networking sites, **activates the reward systems** in the brain the same way as food and sex do

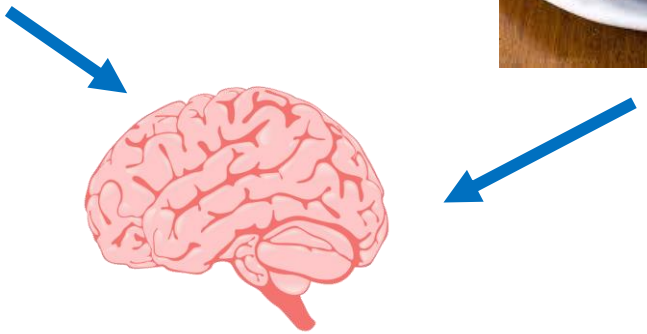


Tamir, D. I., and Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *PNAS* 109, no. 21, 8038–8043. doi:10:1073/pnas.1202129109.

Sharing effect

- Astonishingly, the participants in this particular experiment were even willing to give up monetary rewards for the opportunity to talk about themselves

- The results also suggest that the existence of a reciprocal cyclical feedback for self-disclosure rewards and perpetuates the sharing of personal information on a basic biochemical level.



Tamir, D. I., and Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *PNAS* 109, no. 21, 8038–8043. doi:10:1073/pnas.1202129109.

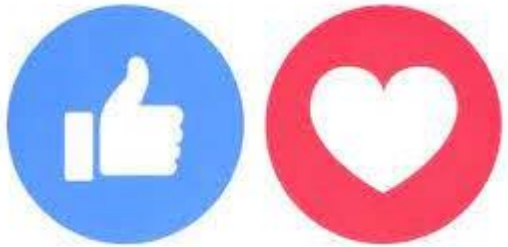
What do we do online? Which are the consequences?

Online activities

Add comments

Biological and psychological consequences

4. “Like” effect and “dopamine” effect



Like effect

- N = 32
- Age = 13-18

Research Article

The Power of the *Like* in Adolescence: Effects of Peer Influence on Neural and Behavioral Responses to Social Media

Lauren E. Sherman[1,2,3], Ashley A. Payton[4], Leanna M. Hernandez[2,4], Patricia M. Greenfield[1,3], and Mirella Dapretto[2,5]

[1]Department of Psychology, University of California, Los Angeles; [2]Ahmanson-Lovelace Brain Mapping Center, University of California, Los Angeles; [3]Children's Digital Media Center @ Los Angeles, University of California, Los Angeles, and California State University, Los Angeles; [4]Interdepartmental Neuroscience Program, University of California, Los Angeles; and [5]Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles

- Aim: investigated a unique way in which adolescent peer influence occurs on social media. The authors developed a novel functional MRI (fMRI) paradigm to simulate Instagram, a popular social photo-sharing tool, and measured teens' behavioral and neural responses to likes, a quantifiable form of social endorsement and potential source of peer influence.
- 120 photographs, 40 personally uploaded by participants

Sherman et al., 2016, Psychological Science

Like effect

- Adolescents underwent fMRI while viewing photos ostensibly submitted to Instagram.
- They were more **likely to *like* photos depicted with many likes than photos with few likes**.
- This finding showed the influence of virtual peer endorsement and held for both neutral photos and photos of risky behaviors (e.g., drinking, smoking).

Fig. 1. Two examples of stimuli presented during the imaging paradigm. Participants saw innocuous photos of adolescents or everyday objects (e.g., the coffee drinks on the left) or images of objects related to risky behavior (e.g., the marijuana cigarette on the right) or adolescents engaging in risky behaviors. Images appeared as they would have in the Instagram app on a smartphone in the year 2014: The number of likes was displayed underneath each photo next to a heart icon, and the Instagram menu buttons were displayed beneath the likes. Finally, there were two buttons allowing participants to like an image ("♥Like") or to move on without liking the image ("→Next").

Sherman et al., 2016, Psychological Science

Like effect

- Viewing photos **with many** (compared with few) likes was associated with **greater activity** in neural regions implicated in reward processing, social cognition, imitation, and attention.
- Areas: precuneus, medial prefrontal cortex, and hippocampus (Mars et al., 2012; Zaki & Ochsner, 2009), as well as the inferior frontal gyrus, which is implicated in imitation (Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008).

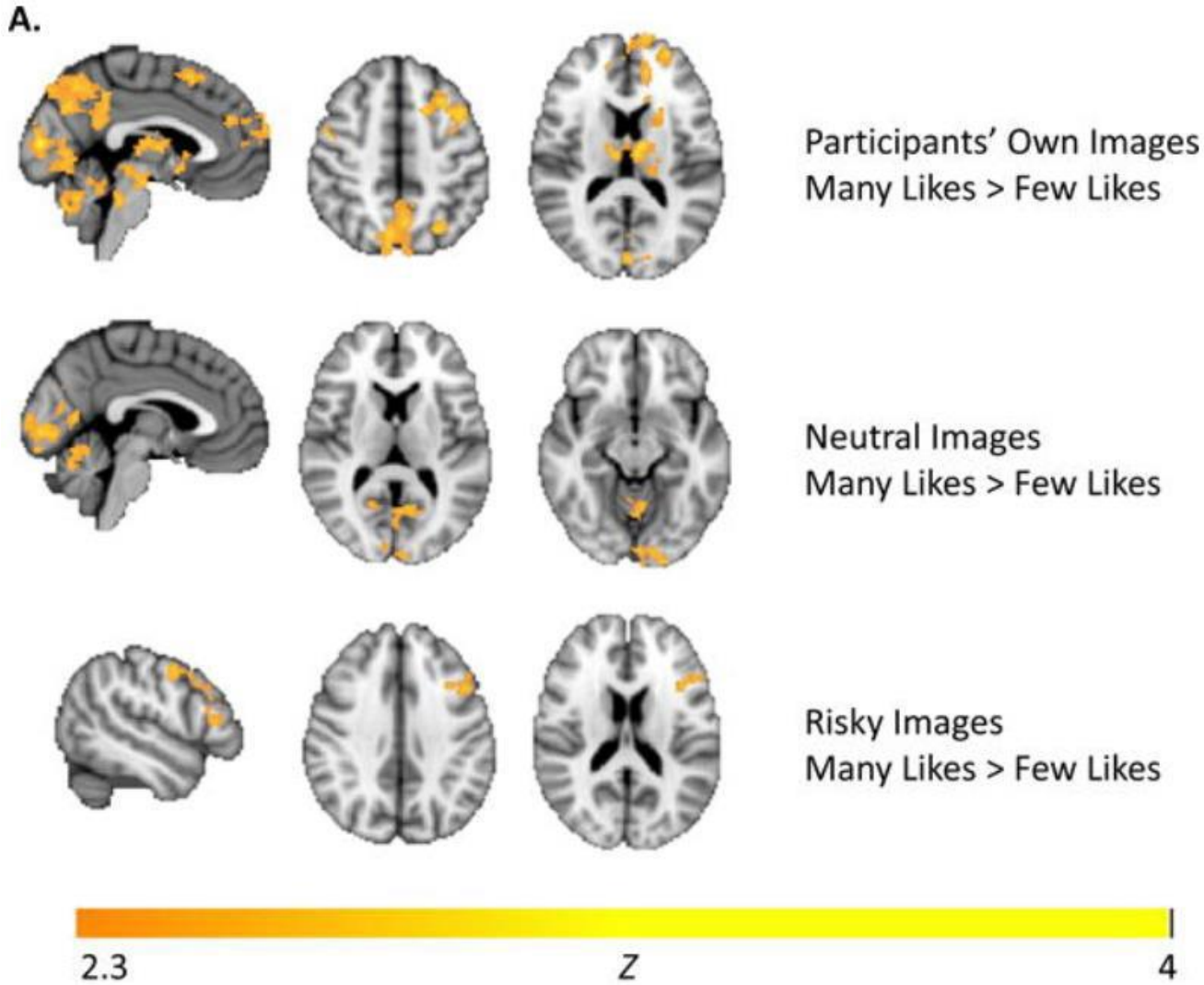
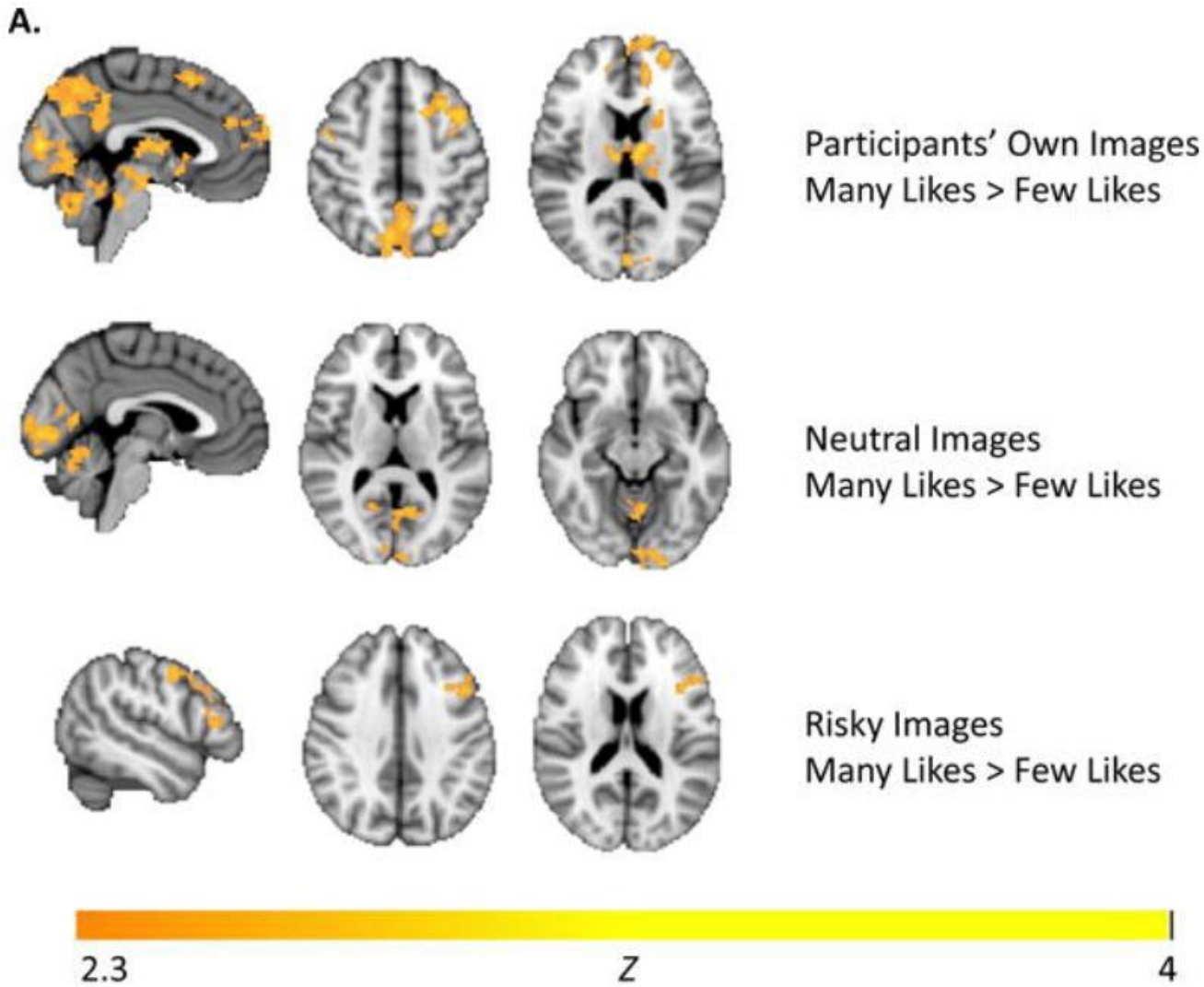


Fig. 2. Neural responses to Instagram photos with many likes compared with photos with few likes. The brain maps in (a) show neural regions with significant activity ($z > 2.3$, cluster corrected at $p < .05$) for the many likes > few likes contrast, for each of the three types of photos.

Sherman et al., 2016, Psychological Science

Like effect

- When participants viewed their own photographs or neutral photographs ostensibly submitted by peers, greater activity in the **visual cortex** was observed in response to photos with many likes compared with photos with few likes.
- The increased activation suggests that participants may have scanned popular images with greater care.



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Sherman et al., 2016, Psychological Science

Like effect

- **Conclusions**: Taken together, imaging findings suggest that adolescents perceive information online in a qualitatively different way when they believe that this information is valued more highly by peers.

Sherman et al., 2016, Psychological Science

Published in final edited form as:
Child Dev. 2018 January ; 89(1): 37–47. doi:10.1111/cdev.12838.

"Peer Influence Via Instagram: Effects on Brain and Behavior in Adolescence and Young Adulthood"

Like effect

- This study replicates the previous one, adding information about brain imaging activation stratifying population by age.
- Mobile social media often feature the ability to "Like" content posted by others. The present study examined the effect of Likes on youths' neural and behavioral responses to photographs
- High school (N= 34, age 16.8) and college students (N = 27, ages 19,9) viewed theirs and others' Instagram photographs while undergoing fMRI.

Published in final edited form as:
Child Dev. 2018 January ; 89(1): 37–47. doi:10.1111/cdev.12838.

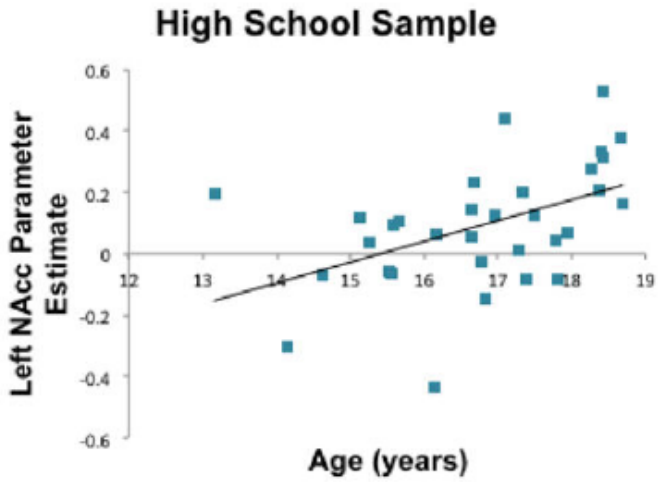
"Peer Influence Via Instagram: Effects on Brain and Behavior in Adolescence and Young Adulthood"

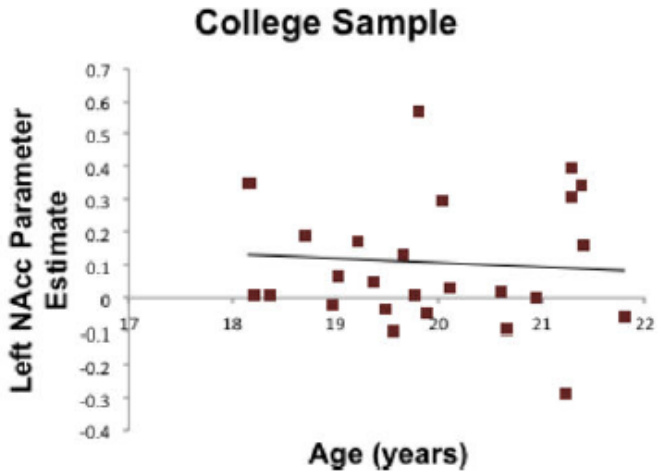
Like effect

- **First result**: confirmation of previous data

- Participants more often Liked photos that appeared to have received many (vs. few) Likes.
- Popular photos elicited greater activity in multiple brain regions, including the nucleus accumbens (Nacc), a hub of the brain's reward circuitry.

Like effect





Second results:

Nucleus accumbens responsivity **increased** with age for high school but not college students

Figure 2. NAcc response to social reward and its relation to age
For participants in the high school cohort, NAcc response to the Popular (Many Likes) > Unpopular (Few Likes) contrast increased linearly with age (Left NAcc: r = .47, p = .006). However, for participants in the college cohort, NAcc response was not associated with age (Left NAcc: r = -.07, p = .72). Responses differed significantly for the high school and college samples in the Left NAcc, depicted in the figure. Parameter estimates are reported in percent signal change, determined using an isolated 3-second event with a double-gamma HRF. The NAcc region of interest was selected from an independent sample of young adults completing a Monetary Incentive Delay task (Tamir & Mitchell, 2013).

Like effect

Third result:

When viewing images depicting risk-taking (vs. non-risky photographs), high school students, but not college students, showed decreased activation of neural regions implicated in cognitive control.

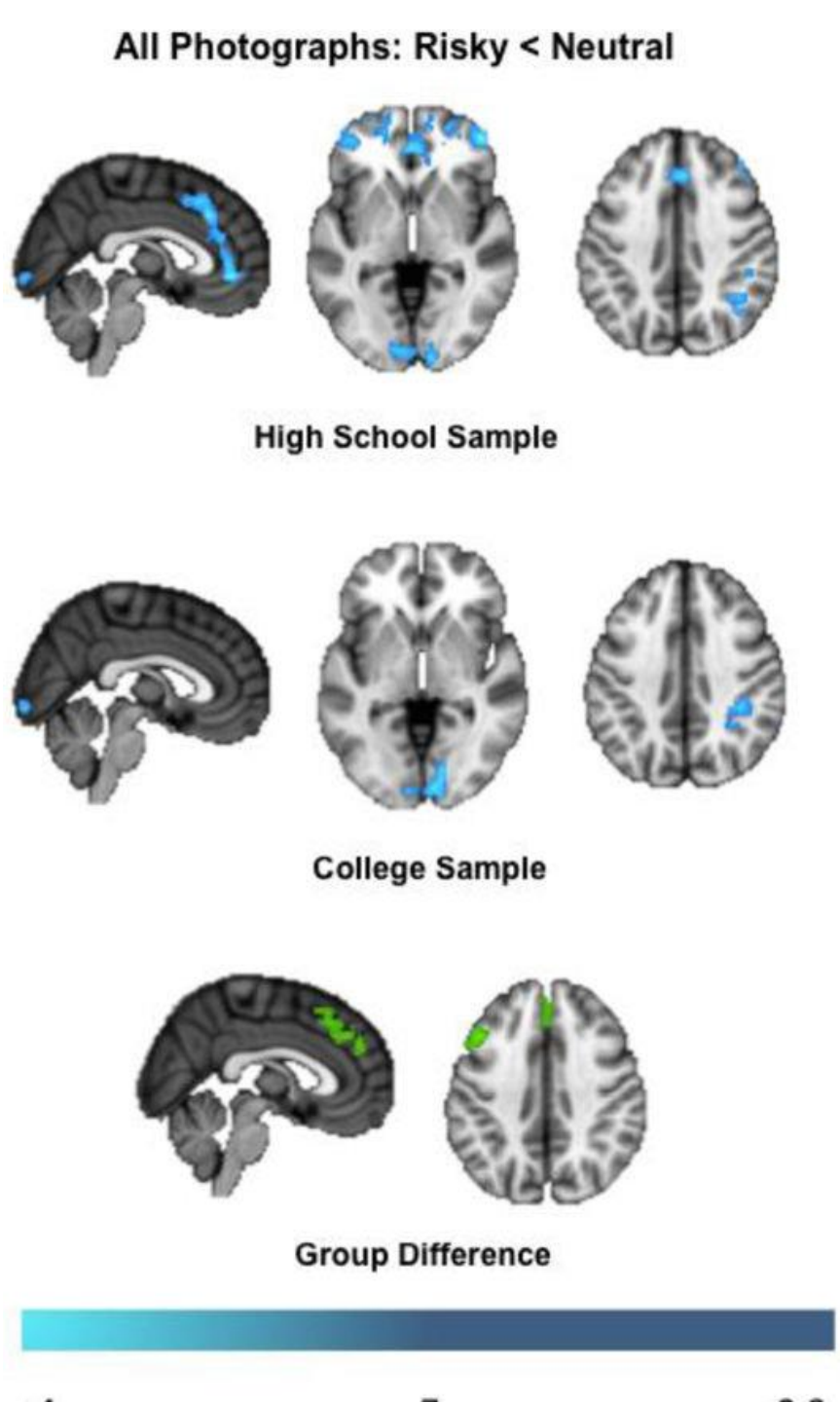


Figure 3. Differences in decreased activation for comparison of risky and neutral photographs
When viewing Instagram photographs depicting risk-taking activities, compared to photographs depicting non-risky, neutral activities, only high-school students showed a significant decrease in activity in frontal regions including the dorsomedial prefrontal cortex (dmPFC) and the dorsolateral prefrontal cortex (dlPFC). The high school and college samples differed significantly in the dmPFC and left dlPFC, depicted in green.

Conclusions

- Quantifiable Social Endorsement (QSE) plays a significant role in influencing how young adults perceive and respond to information on social media; in other words, QSE is a mechanism of peer influence, and a potential means by which individuals learn about their social environment, in a wider age-range than previously shown.
- These findings make intuitive sense given the continuing importance of the peer context in emerging adulthood (Arnett, 2000) and the popularity of mobile social media among college students

Conclusions

- While the present study focused specifically on peer influence, it is possible that non-peers (e.g., older adults, parents, etc.) might have a similar effect, in line with work suggesting overlapping mechanisms between peer and parental influence.

- Increased age was associated with greater NAcc response to having one's own content Liked by peers in the high school but not college sample. This finding is consistent with recent longitudinal work in adolescents demonstrating that NAcc sensitivity to rewarding stimuli increases in adolescence and peaks around age 16–17.

- Social reward may progress along a similar trajectory as monetary reward.

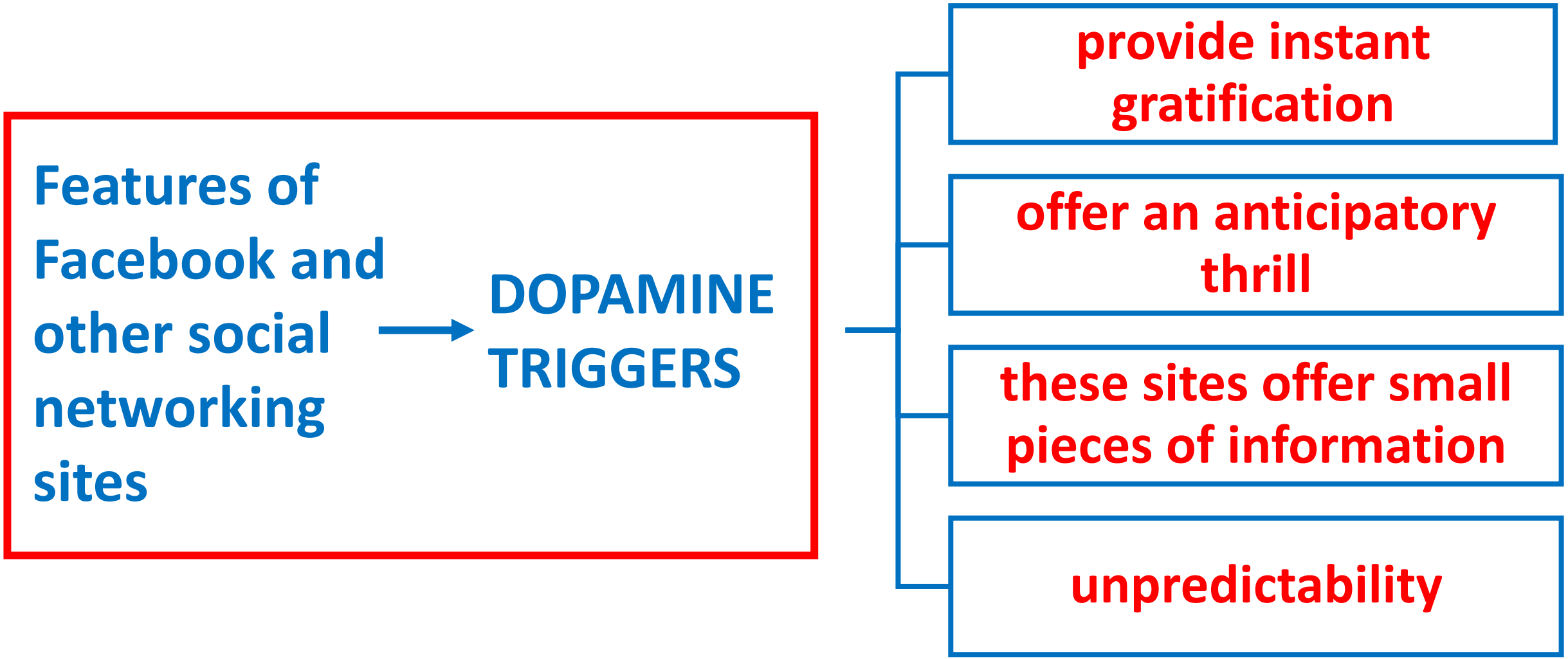
Dopamine effect

- If social networking is rewarding and exciting, it is very likely that social networking might serve as another trigger for the release of **dopamine** in the brain.

- Specific **features of Facebook and other social networking sites** might make them triggers for dopamine release

Weinschenk, S. (November 7, 2009).

Dopamine effect



Weinschenk, S. (November 7, 2009).

What do we do online? Which are the consequences?

Online activities

Interact with “friends”

Biological and psychological consequences

5. Seeking attention and positive feedbacks
6. Change of friends
7. Change of communication style

Effects of the digital world on relationship

- In 1987, according to one estimate, we spent on average 6 hours per day in face-to-face social interaction, and 4 via electronic media.

- In 2007 the proportion had reversed, with almost 8 hours a day spent socializing via electronic media, and only 2,5 hours in face-to-face social interaction

Ofcom. (2013). *Adults' media use and attitudes report*.
Madden et al., (2013). *Teens and technology 2013*.
Arbitron Inc. and Edison Research. (2013). *The infinite dial 2013: Navigating digital platforms*.
Smith, C. (2013). By the numbers: 32 amazing Facebook stats [blog post, updated June 2013]. Arbitron Inc. and Edison Research, 2013.

Use of internet for social activities

- In UK: The 64% of internet users (age > 16) also used social networking sites → 92% of teenagers (age: 16-19)

- In USA: 80% of teenagers (age: 12-17) used social networking sites (Facebook and Myspace)

Ofcom. (2013). *Adults' media use and attitudes report*.
Madden et al., (2013). *Teens and technology 2013*.
Arbitron Inc. and Edison Research. (2013). *The infinite dial 2013: Navigating digital platforms*.
Smith, C. (2013). By the numbers: 32 amazing Facebook stats [blog post, updated June 2013]. Arbitron Inc. and Edison Research, 2013.

Most popular social networks of teenagers in the United States from fall 2012 to fall 2019

	Fall 2012	Spring 2013	Fall 2013	Spring 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Snapchat	-	-	-	-	11%	17%	24%	35%	39%	47%	45%	46%	41%	44%
Instagram	12%	17%	27%	30%	29%	29%	23%	24%	23%	24%	26%	32%	35%	35%
TikTok	-	-	-	-	-	-	-	-	-	-	-	-	0%	4%
Twitter	27%	30%	31%	27%	21%	18%	16%	13%	11%	7%	9%	6%	6%	3%
Facebook	42%	33%	27%	23%	12%	13%	15%	13%	11%	9%	8%	6%	6%	3%
Pinterest	2%	2%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	3%
Tumblr	3%	4%	5%	5%	4%	3%	2%	-	-	-	-	-	-	-
Google+	6%	5%	4%	4%	1%	1%	1%	1%	-	-	-	-	-	-
Other	2%	4%	2%	4%	8%	8%	5%	-	-	-	-	-	-	-

How many friends do you have?

- In the United States, 80 percent of online teens ages twelve to seventeen use social networking sites, mostly Facebook and MySpace.
- U.S. users have on average 262 friends, a figure higher than the world average of roughly 140 friends.
- Twelve-to twenty-four-year-old Facebook users have, on average, more than five hundred Facebook friends. Roughly, 22 percent are from high school, 12 percent are immediate family, 10 percent are co-workers, 9 percent are from college, and 10 percent of friends have never been met in person or only been met once

Ofcom. (2013). *Adults' media use and attitudes report*.
Madden, M., Lenhart, A., Duggan, M., Cortesi, S., and Gasser, U. (2013). *Teens and technology 2013*.
Arbitron Inc. and Edison Research. (2013). *The infinite dial 2013: Navigating digital platforms*.
Smith, C. (2013). By the numbers: 32 amazing Facebook stats [blog post, updated June 2013]. Arbitron Inc. and Edison Research, 2013.

How many friends do you have?

- On an average day, 26 percent of Facebook users “like” a friend’s status, 22 percent comment on a friend’s status, while only 15 percent update their own status.
- So more people spend time interacting with other users’ content rather than posting their own

Ofcom. (2013). *Adults’ media use and attitudes report*.
Madden, M., Lenhart, A., Duggan, M., Cortesi, S., and Gasser, U. (2013). *Teens and technology 2013*.
Arbitron Inc. and Edison Research. (2013). *The infinite dial 2013: Navigating digital platforms*.
Smith, C. (2013). By the numbers: 32 amazing Facebook stats [blog post, updated June 2013]. Arbitron Inc. and Edison Research, 2013.

Idea of friendship

- Miller McPherson compare ideas of friendship in 1985 with those in 2004.
- McPherson's team discovered that the 2004 subjects had fewer people they could really talk to, with the number of available confidants down by about a third.
- Even more alarming, the proportion of those having no one at all with whom they could discuss important matters had nearly tripled

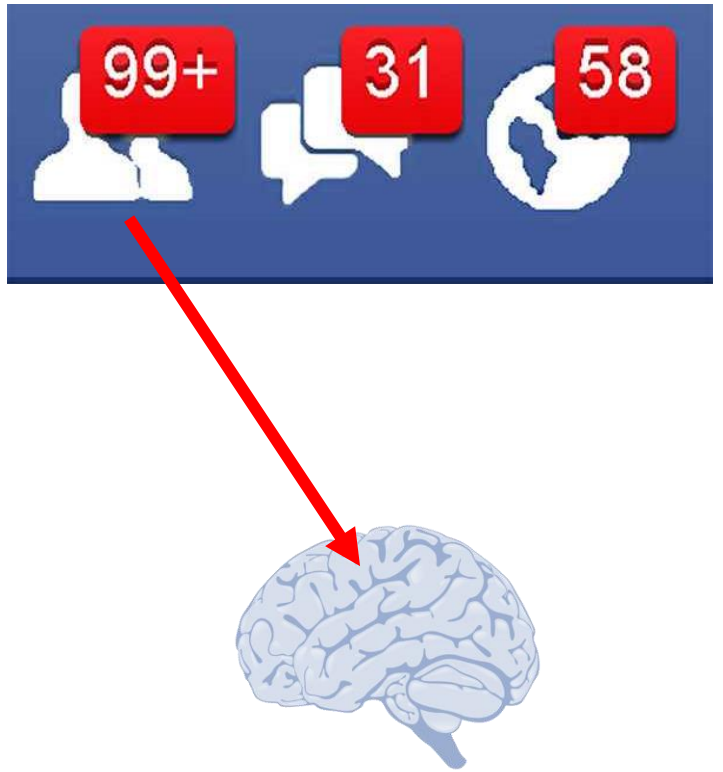
McPherson, M., Smith-Lovin, L., and Brashears, M. E. (2006). Social isolation in America: Changes in core discussion networks over two decades. *American Sociological Review* 71, no. 3, 353–375. doi:10:1177/000312240607100301

Social networking and brain

Do social networking map directly onto the physical brain?

The size of an individual's online social network is closely linked to certain aspects of physical brain structures implicated in social cognition.

Kanai et al. found that variation in the number of friends on Facebook strongly and significantly predicted the size of certain brain structures.

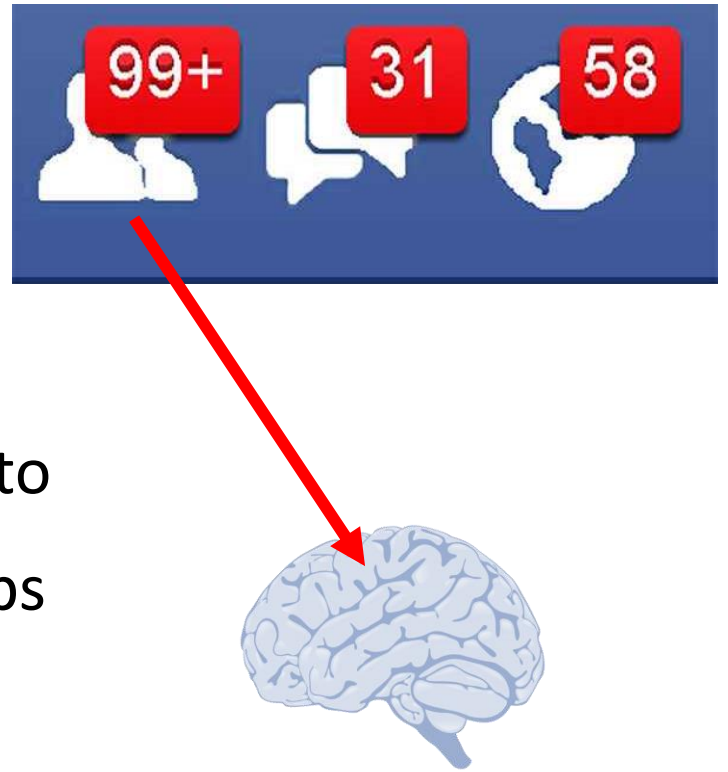


Kanai, R., Bahrami, B., Roylance, R., and Rees, G. (2011). Online social network size is reflected in human brain structure. *Proceedings of the Royal Society Biological Sciences* 279, no. 1732, 1327–1334. doi:10:1098/rspb.2011:1959.

Social networking and brain

N = 40

Age: 12-30 years

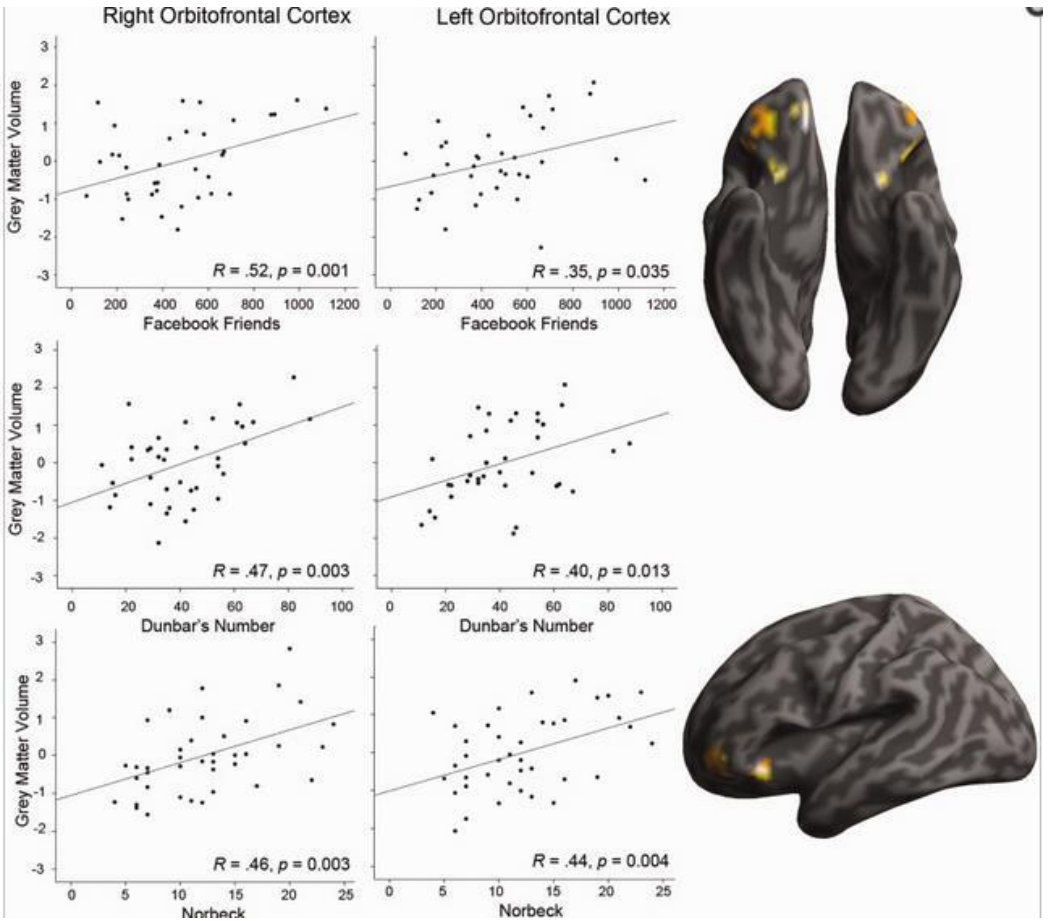


Measures to establish social network extension:

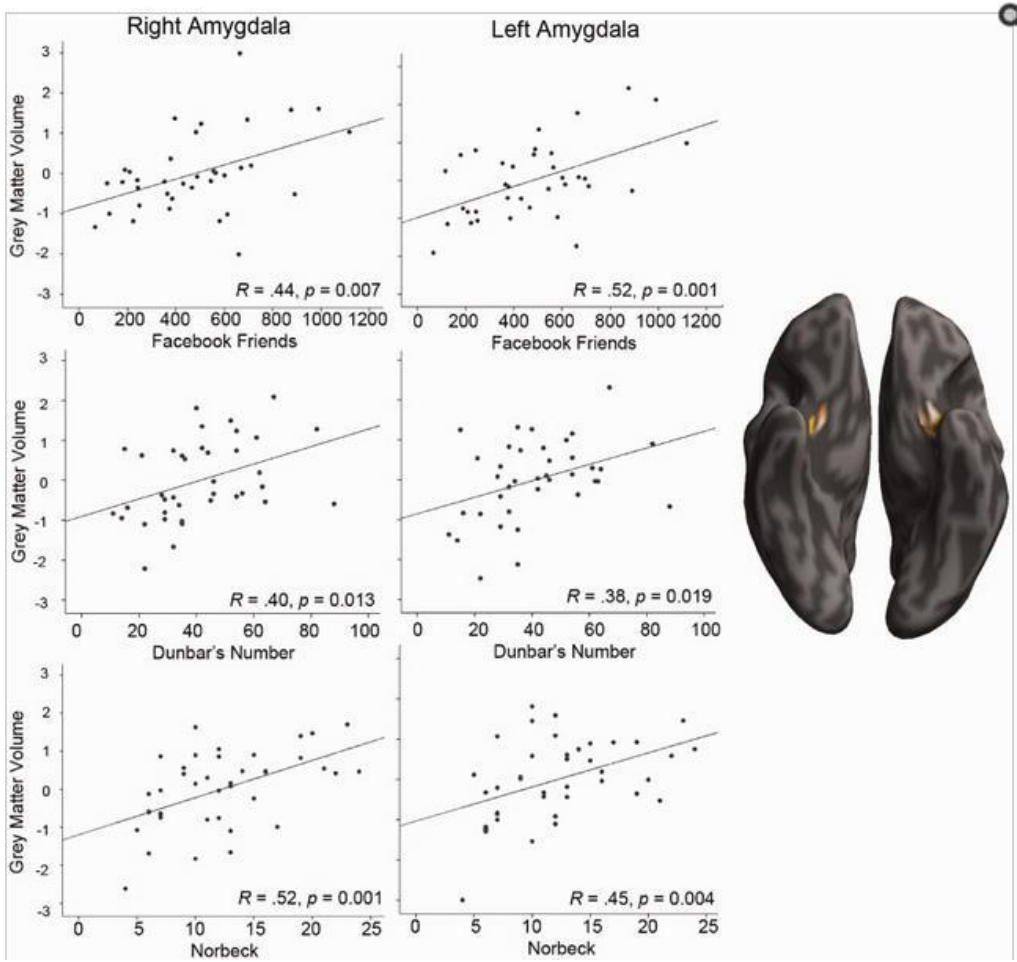
1) Facebook friends
2) Dunbar's Number (is a suggested cognitive limit to the number of people with whom one can maintain stable social relationships—relationships in which an individual knows who each person is and how each person relates to every other person)
3) Norbeck Social Support Group Questionnaire

Kanai, R., Bahrami, B., Roylance, R., and Rees, G. (2011). Online social network size is reflected in human brain structure. *Proceedings of the Royal Society Biological Sciences* 279, no. 1732, 1327–1334. doi:10:1098/rspb.2011:1959.

Social networking and brain



The gray matter density of particular brain regions (**orbitofrontal cortex** and **amygdala**), is linked to social network size in the real world, and also correlated with the extent of a subject's online social network



Kanai, R., Bahrami, B., Roylance, R., and Rees, G. (2011). Online social network size is reflected in human brain structure. *Proceedings of the Royal Society Biological Sciences* 279, no. 1732, 1327–1334. doi:10:1098/rspb.2011:1959.

Changes in communication style

- In 2012, the British communications watchdog Ofcom produced its ninth annual Communications Market Report.

- The average person was now sending fifty texts a week

- A staggering 96 percent of young people ages sixteen to twenty-four were using instant message (non-oral) communication—email, text message, or a social network—every day to contact friends and family. Meanwhile, verbal communication over the phone or in person has become correspondingly less popular, with only 63 percent talking face-to-face with friends or family daily

Ofcom. (July 18, 2012). *The communications market report 2012*

Changes in communication style

Although Digital Natives may prefer non-oral communication through text messaging or the Internet…

…the type of emotional support that can be provided by these forms of communication turns out to be very inferior.

Ofcom. (July 18, 2012). *The communications market report 2012*

Changes in communication style

Published in final edited form as:
Evol Hum Behav. 2012 January ; 33(1): 42–45.

Instant messages vs. speech: hormones and why we still need to hear each other

Leslie J. Seltzer[a,b,*], **Ashley R. Prososki**[a], **Toni E. Ziegler**[c], and **Seth D. Pollak**[a,b]
[a]Department of Psychology, Waisman Center, University of Wisconsin-Madison, Madison, WI 53703, USA
[b]Department of Anthropology, University of Wisconsin-Madison, Madison, WI 53703, USA
[c]Wisconsin National Primate Research Center, Madison, WI 53705, USA

Speech between trusted individuals is capable of:

- reducing levels of salivary cortisol
- increasing levels of urinary oxytocin

Seltzer, L. J., Prososki, A. R., Ziegler, T. E., and Pollak, S. D. (2012). Instant messages vs. speech: Hormones and why we still need to hear each other. *Evolution and Human Behavior* 33, 42–45.

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[a]Department of Psychology, Waisman Center, University of Wisconsin-Madison, Madison, WI 53703, USA
[b]Department of Anthropology, University of Wisconsin-Madison, Madison, WI 53703, USA
[c]Wisconsin National Primate Research Center, Madison, WI 53705, USA

It is not clear, however, whether it is the uniquely human grammar, syntax, content and/or choice of words that causes these physiological changes, or whether the prosodic elements of speech, which are present in the vocal cues of many other species, are responsible.

Seltzer, L. J., Prososki, A. R., Ziegler, T. E., and Pollak, S. D. (2012). Instant messages vs. speech: Hormones and why we still need to hear each other. *Evolution and Human Behavior* 33, 42–45.

Changes in communication style

Published in final edited form as:
Evol Hum Behav. 2012 January ; 33(1): 42–45.

Instant messages vs. speech: hormones and why we still need to hear each other

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[a]Department of Psychology, Waisman Center, University of Wisconsin-Madison, Madison, WI 53703, USA
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Researchers at the University of Wisconsin–Madison asked the following question: could the **content alone** of an emotionally supportive conversation between a parent and a teenager **convey reassurance**, or would the tone of voice and/or physical presence of the parent also play a role?

Seltzer, L. J., Prososki, A. R., Ziegler, T. E., and Pollak, S. D. (2012). Instant messages vs. speech: Hormones and why we still need to hear each other. *Evolution and Human Behavior* 33, 42–45.

Changes in communication style

No support

Seltzer, L. J., Prososki, A. R., Ziegler, T. E., and Pollak, S. D. (2012). Instant messages vs. speech: Hormones and why we still need to hear each other. *Evolution and Human Behavior* 33, 42–45.

Changes in communication style

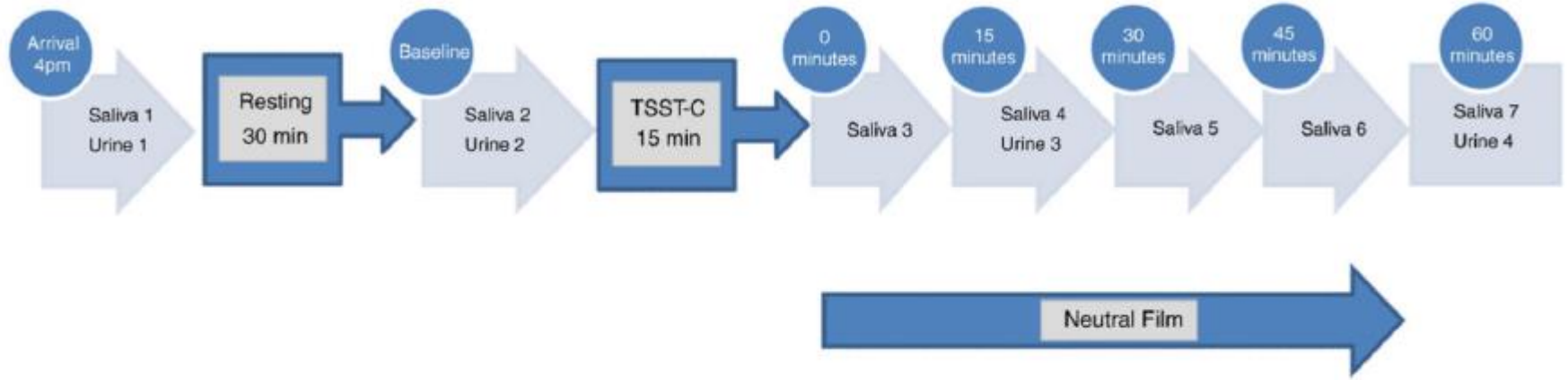
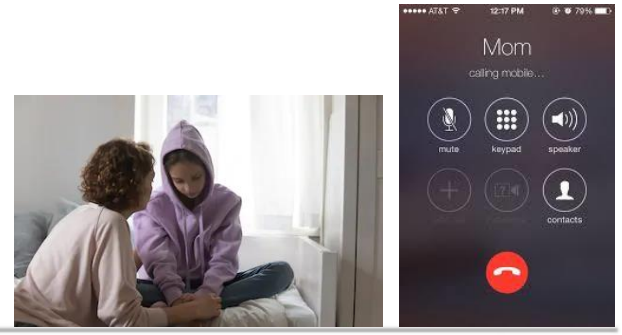


Fig. 1.
Experimental time course.

Changes in communication style

Teenagers who spoke with their parents over the phone or in person released similar amounts of oxytocin and showed similar **low levels of cortisol**, indicative of a reduction in stress. In comparison, those who instant-messaged their parents released no oxytocin and had salivary cortisol levels, as high as those who did not interact with their parents at all



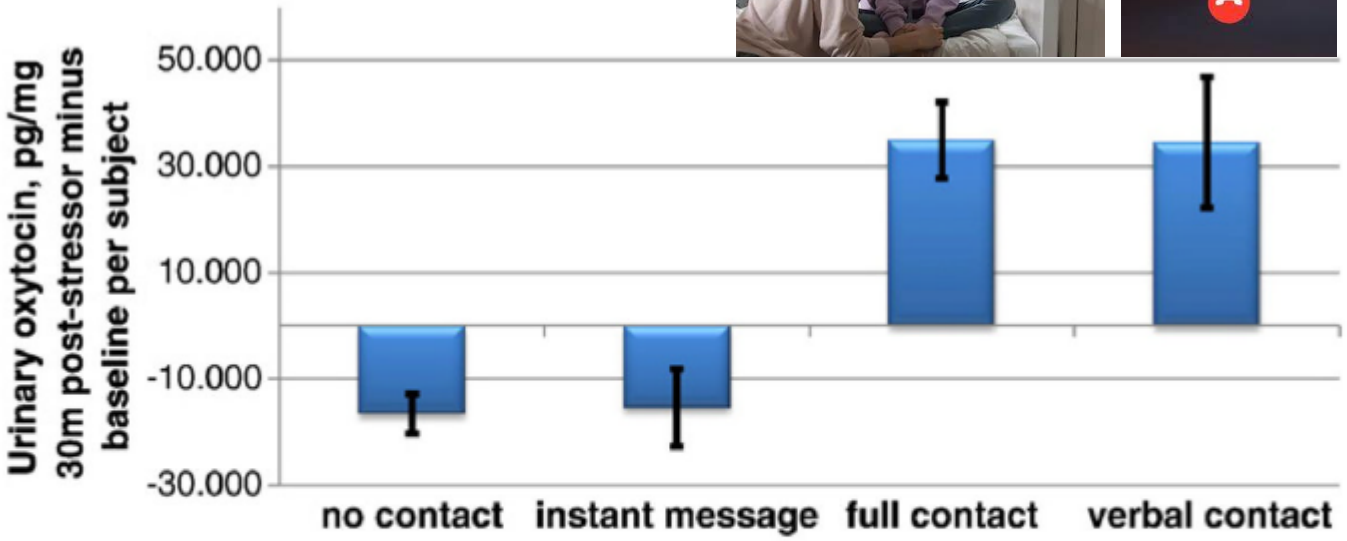


Fig. 3.
Urinary oxytocin in girls using instant messages to communicate via instant message is also similar to that in girls who have no interaction with their parents at all and is unlike the higher levels observed in girls able to touch or hear the sound of their parents' voice. Urinary oxytocin is pg/mg creatinine.

Changes in communication style

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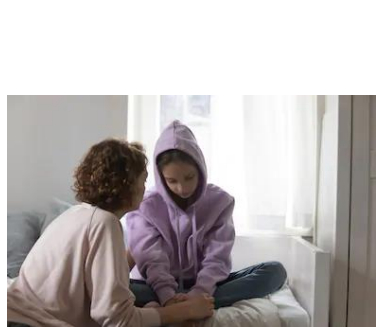

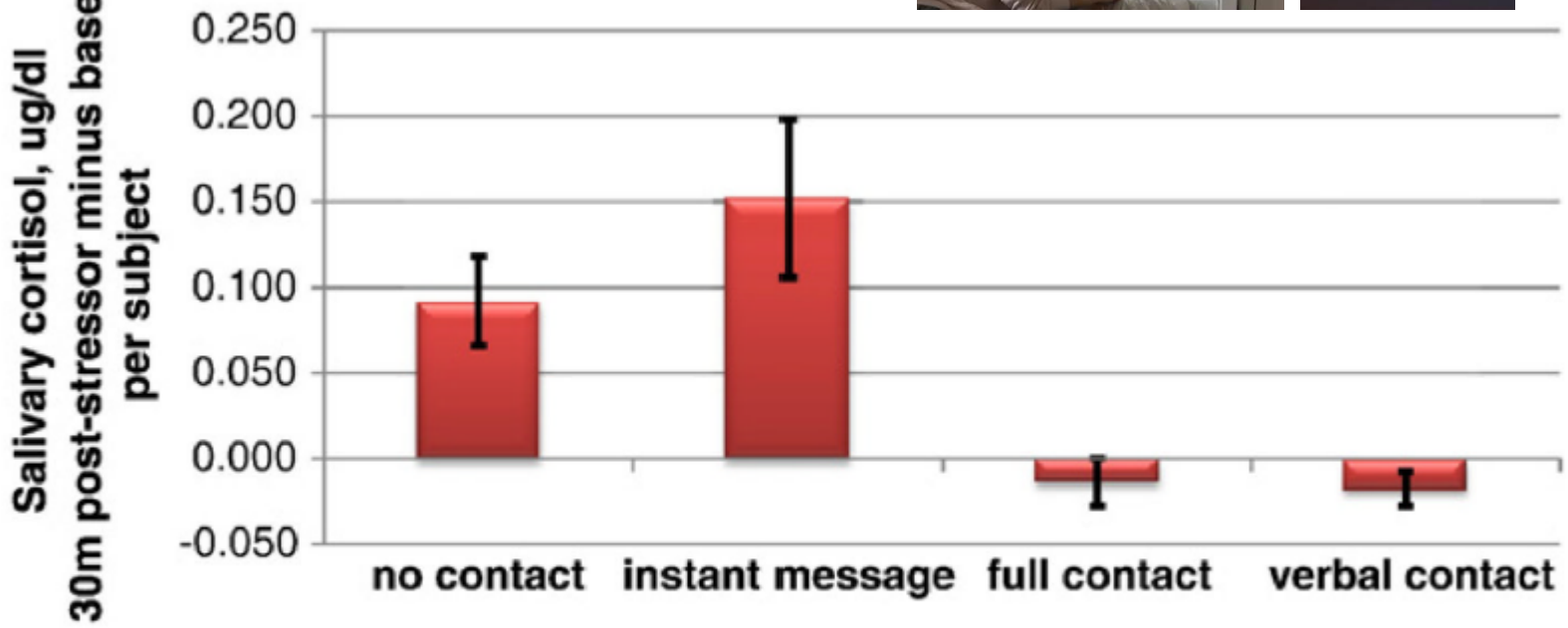

Fig. 2.
Salivary cortisol levels are comparable between children communicating via instant messaging and those who do not communicate with their accompanying parent at all following a laboratory stressor.

Empathy levels

- Change of communication → reduced interactions → change of empathy.
- A survey of fourteen thousand U.S. college students suggests that levels of empathy may be declining.
- A huge drop in the curve is related to the last decade, a period that corresponds to the increase of social networking among Digital Natives

Konrath, S. H., O'Brien, E. H., and Hsing, C. (2011). Changes in dispositional empathy in American college students over time: A meta-analysis. Personality and Social Psychology Review 15, no. 2, 180–198.

Reduction of face-to-face interactions and empaty

- Possible trend: an increase in online relationships and a decrease in empathy

- Beyond empathy, excessive Internet use could lead more generally to a **reduced ability to communicate effectively**, as it has been associated with a lack of emotional intelligence, including **poor performance in interpreting facial expressions**.
- Perhaps it is unsurprising that people who spend excessive amounts of time on the Internet have deficits in face processing

CYBERPSYCHOLOGY, BEHAVIOR, AND SOCIAL NETWORKING
Volume 14, Number 5, 2011

DOI: 10.1089/cyber.2009.0333

Face processing is compromised

Deficits in Early-Stage Face Perception in Excessive Internet Users

Jin-bo He, Ph.D.,[1] Chia-ju Liu, Ph.D.,[2] Yong-yu Guo, Ph.D.,[1] and Lun Zhao, Ph.D.[3,4]

Excessive Internet use is associated with a limited ability to communicate effectively socially, which depends largely on the capacity for perception of the human face.

Authors used a passive visual detection paradigm to compare the early stages of the processing of face-related information in **young excessive Internet users (EIUs)** and **healthy normal subjects** by analyzing event-related potentials (ERPs) elicited by faces and by nonface stimuli (tables), each presented in the upright and inverted position.

He, J. B., Liu, C. J., Guo, Y. Y., and Zhao, L. (2011). Deficits in early stage face perception in excessive Internet users. *Cyberpsychology, Behavior, and Social Networking* 14, no. 5, 303–308. doi:10:1089/cyber.2009:0333.

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FIG. 1. Examples of faces and objects, as well as target flowers, used as stimuli for the P1 and N170 components of the ERP spectrum in EIUs and normal controls.

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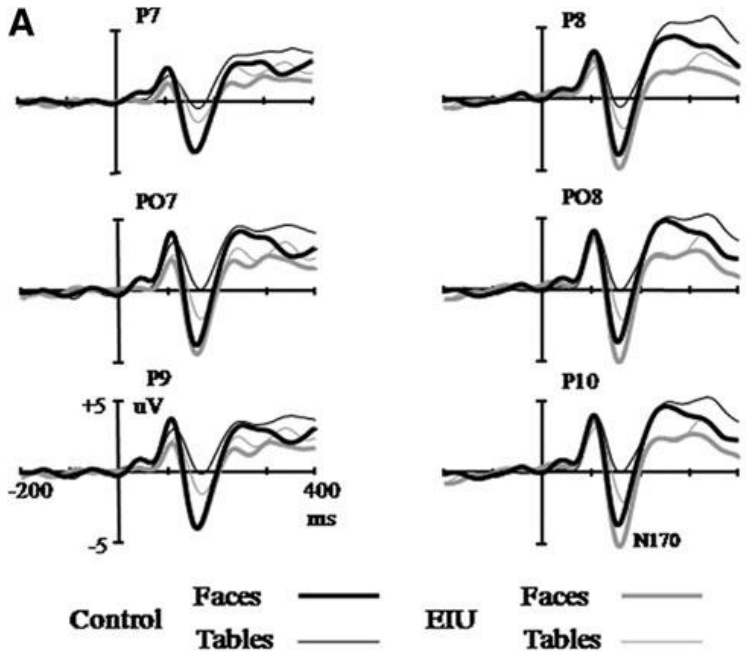

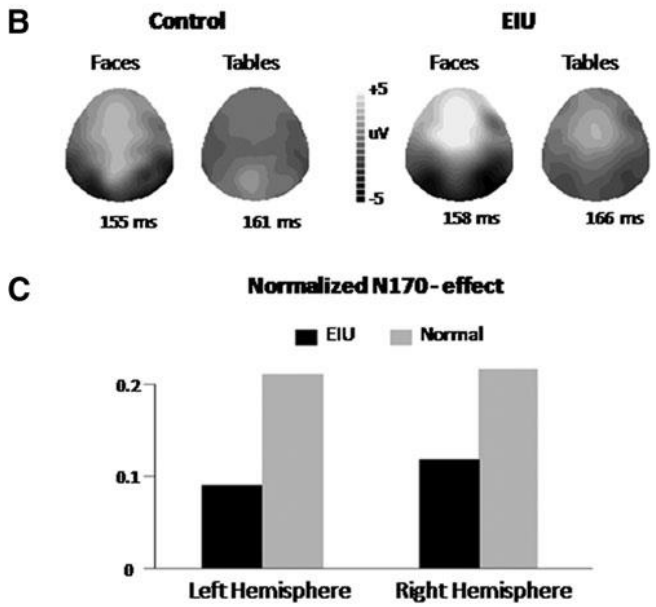

FIG. 2. Grand averaged ERPs elicited by upright faces and tables at left and right occipital-temporal sites (A), 2D topographic map of N170 peak amplitude (B), and normalized values of the N170 face effect in EIUs and normal control groups (C).

The P1 and N170 components of the spectrum of ERPs elicited at occipital–temporal sites by the viewing of **faces** were **larger** and peaked sooner than the same ERP components elicited by tables, and inverted faces significantly enhanced and delayed the N170 component. This meant that the faces had more significance for the average observer than the objects. **EIUs had a generally smaller P1 component** than did normal subjects, whether elicited by faces or by tables, and the N170 effect, or difference in amplitude of the N170 component for faces versus tables, was significantly smaller in the EIUs than in normal subjects.

Face processing is compromised

- This impairment could be similar to the impairment of autistic people.

- In the United Kingdom alone, more than half a million people—around 1 percent of the population—have a form of autism. Autism spectrum disorders are characterized by a triad of impairments:
  1. difficulty with **social communication**, both verbal and nonverbal, such that patients often find it hard to “read” other people;
  2. difficulty **recognizing or understanding other people’s emotions** and feelings, as well as expressing their own; and
  3. difficulty with social imagination, namely, **understanding and predicting other people’s behavior**, making sense of abstract ideas, and imagining situations outside their immediate daily routine.

Face processing is compromised

- Is there a connection between autistic-like traits and the use of social networking?

- Two crucial aspects:

1. autistic people are generally most comfortable in cyberspace: in such a world, there is no need to understand what might be going on inside the minds of others—what you see is what you get
2. different learning screen-based approaches improve autistic people: design programs in which peers can explore and improve social and communicative skills through interacting and collaborating with virtual characters (agents) and digital objects

Nacc and online reputation

frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
published: 29 August 2013
doi: 10.3389/fnhum.2013.00439

Nucleus accumbens response to gains in reputation for the self relative to gains for others predicts social media use

Dar Meshi[1,2,3,4]*, *Carmen Morawetz*[1,2,3] *and Hauke R. Heekeren*[1,2,3,4]

[1] *Cluster of Excellence "Languages of Emotion," Freie Universität Berlin, Berlin, Germany*
[2] *Department of Education and Psychology, Freie Universität Berlin, Berlin, Germany*
[3] *Dahlem Institute for the Neuroimaging of Emotion, Freie Universität Berlin, Berlin, Germany*
[4] *Berlin School of Mind and Brain, Humboldt Universität zu Berlin, Berlin, Germany*

- The processing of gains in reputation (positive social feedback related to one's character) occurs in the ventral striatum.
- Furthermore, discovering that others like us, or have provided general positive feedback about us, is also processed in the ventral striatum.
- The ventral striatum, which includes the nucleus accumbens, has been well-established in the processing of other rewards which motivate human behavior, such as money or food.

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- In today's world, we can obtain a good reputation in a variety of ways; for example, we can be polite to people or behave in a moral manner. We can also manage our **reputation online** via social media websites.

- Aim of the study: authors employed Facebook use as a proxy for a real-world behavior aimed at obtaining a good reputation.
- Then, authors selected participants for their Facebook use and, in the scan, participants received gains in reputations, observed the gains in reputations of another person or received money.

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- Authors recruited 31 healthy, right-handed participants (14 males) between 19 and 31 years of age

- Participants were told that between Day 1 and Day 2, the recorded video interview would be individually observed by 10 anonymous reviewers.
- The participants were then told that when they returned for Day 2 of the experiment they would learn what the reviewers thought of them, as well as perform a card choice task where they could earn money

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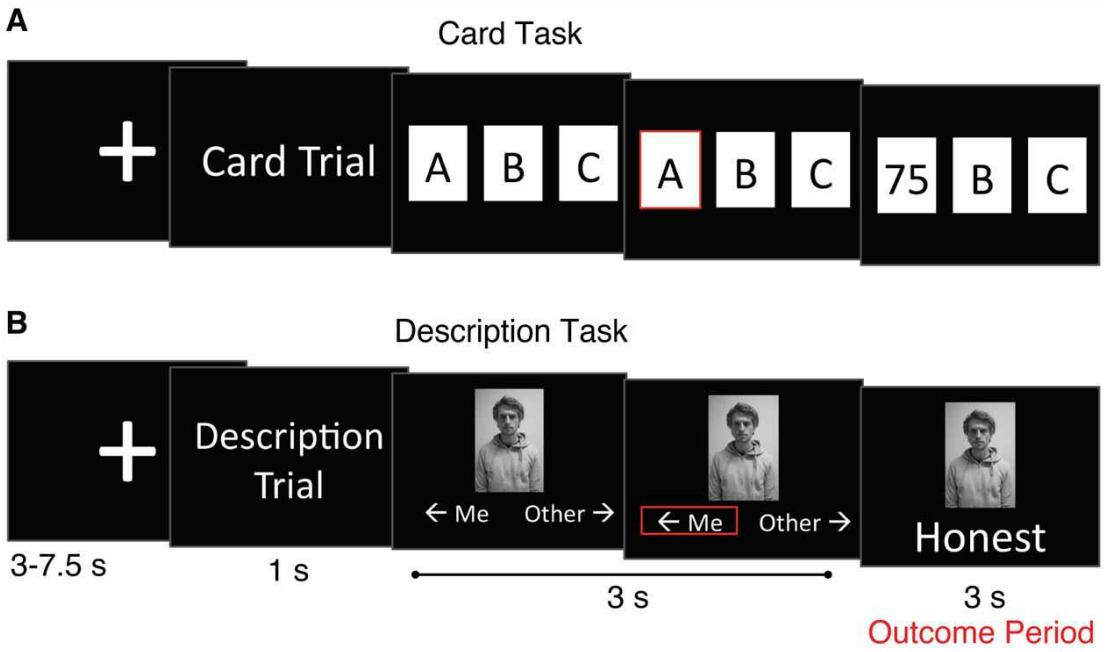

FIGURE 2 | The card and description tasks. At the beginning of each trial, participants were shown a message indicating which type of trial they were about to perform (1 s). **(A)** In the card task, participants were presented with three cards and required to choose one (3 s; answers were confirmed by a red outline around the card). The monetary outcome of their choice was then revealed (3 s). They received either a High-win (75, 80, or 85 cents), a Low-win (25, 30, or 35 cents), or a No-win ("XX") outcome. **(B)** In the description task, participants saw a picture of either themselves or of an "other" person who took part in the experiment (participants were told that this other participant had also completed the on-camera interview and then received feedback). Participants were required to indicate the identity of the person in the picture (3 s; answers were confirmed by a red outline). A word was then displayed below the picture (3 s). Participants believed that this word was selected by the anonymous reviewers to describe the person in the picture. Importantly, the anonymous reviewers did not exist; they were only part of the experimental cover story. In reality, the participants received either a pre-determined range of positive feedback concerning their reputation, a pre-determined range of positive feedback concerning the "other" participant's reputation, or participants saw "xxxxxxxx," which was used as a No-feedback control for both the self and other conditions (see Materials and Methods).

Nacc and online reputation

Results:

1) self-relevant gains in reputation and monetary reward are processed in the ventral striatum
2) across participants, when responding to gains in reputation for the self, compared to observing gains for others, **reward related activity in the left nucleus accumbens predicts Facebook use**.
3) nucleus accumbens activity in response to monetary reward did not predict Facebook use.

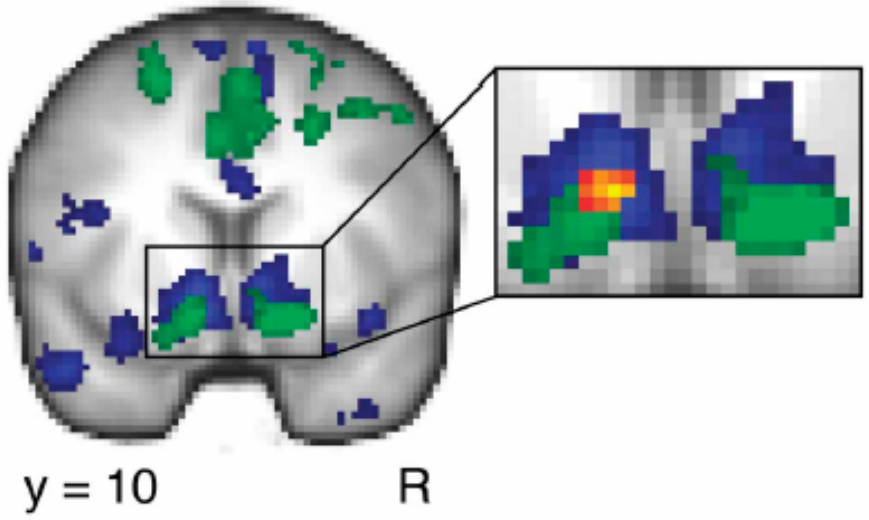

FIGURE 3 | Neuroimaging results demonstrating that Facebook use is predicted by the nucleus accumbens response to self-relevant gains in reputation across participants. The monetary reward contrast (High-win > Low-win in card task) is depicted in blue, and the positive social feedback interaction contrast (Self High-positive feedback > Other High-positive feedback) > (Self Low-positive feedback > Other Low-positive feedback) is depicted in green. The results demonstrate an overlap between monetary and social reward conditions within the ventral striatum. BOLD activation maps thresholded at $Z > 2.3$, $p < 0.05$, cluster corrected. *Box*, Closeup of ventral striatum activity. Analysis at the group level using individual Facebook intensity scores and the positive social feedback interaction contrast was performed within a mask of the bilateral nucleus accumbens. The results demonstrate significant activity within the left nucleus accumbens, shown in red-yellow. BOLD activation thresholded at $Z > 2.3$, $p < 0.05$, cluster corrected for bilateral nucleus accumbens. R, right hemisphere.

Role of Nacc

Behavioural Brain Research 329 (2017) 221–228

Contents lists available at ScienceDirect

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Facebook usage on smartphones and gray matter volume of the nucleus accumbens

Christian Montag[a,b,*], Alexander Markowetz[c], Konrad Blaszkiewicz[c], Ionut Andone[c], Bernd Lachmann[a], Rayna Sariyska[a], Boris Trendafilov[c], Mark Eibes[c], Julia Kolb[d], Martin Reuter[d,e], Bernd Weber[e,f,g], Sebastian Markett[d,e]

In the present study authors combined recorded Facebook usage from smartphones with structural brain scans that were obtained from each smartphone user at the beginning of the experiment. Here, they focused on the nucleus accumbens region that has been highlighted in the study by Meshi.

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N =85 participants (46 males)

- Recorded the actual Facebook usage on their smartphones over the course of five weeks and correlated summary measures of Facebook use with gray matter volume of the nucleus accumbens.

Role of Nacc

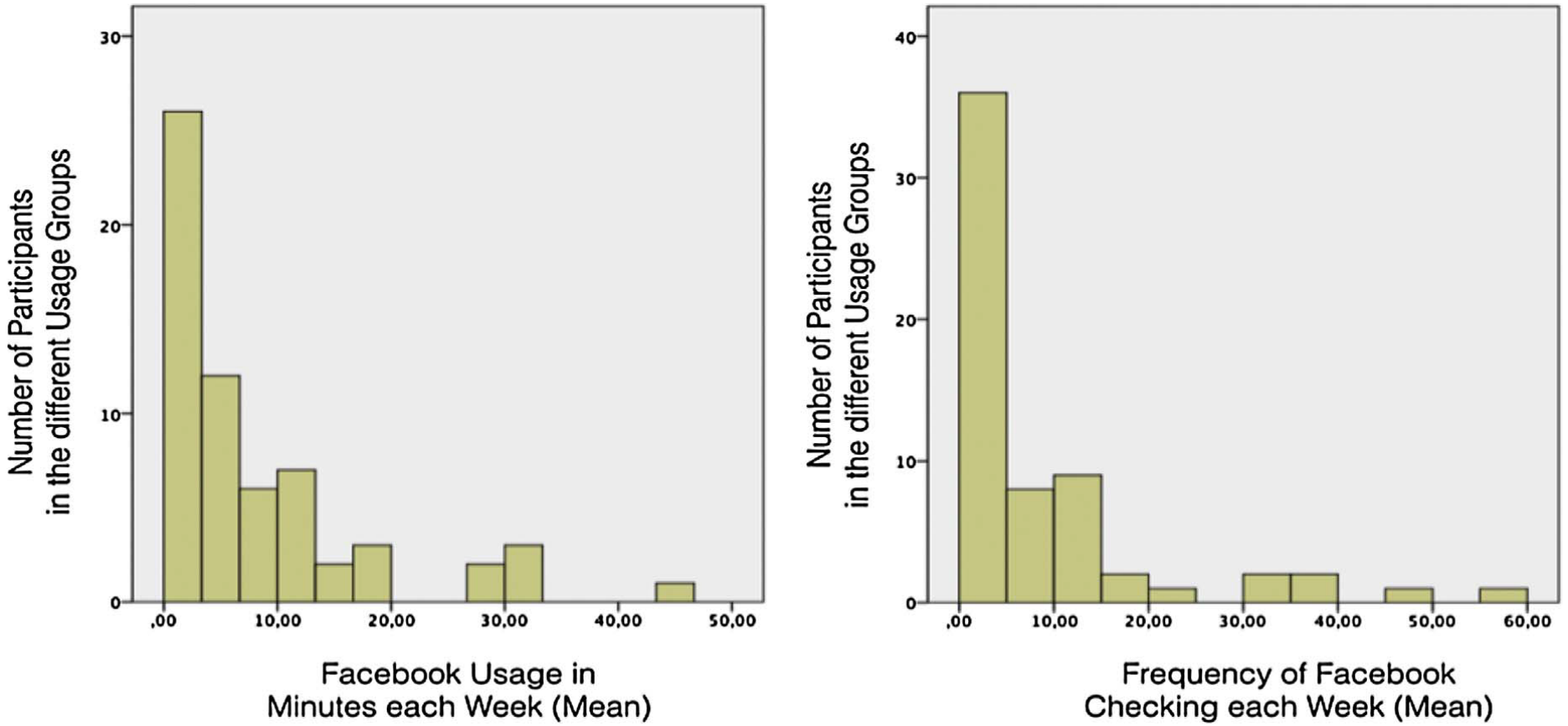

Fig. 3. Distributions of the tracked Facebook variables from the smartphones of the participants.

Role of Nacc

Results:

- Lower volumes of the nucleus accumbens were associated with higher frequency of Facebook checking in everyday life.
- There were also associations between accumbens volume and Facebook duration.
- Facebook duration, however, was less reliable than Facebook frequency over the five weeks period.

Role of Nacc

Results:

- Given the cross-sectional design of the present study, it remains to be elucidated whether lower volumes of the accumbens constitute a factor for increased social media use or whether it results as a consequence of higher usage.

- Interestingly, one recent longitudinal study has identified lower NAcc volumes as risk factors for alcohol use onset in a community sample of adolescents

Role of Nacc

Results:

- In sum, this study gives additional evidence that a) the nucleus accumbens could be involved in online social media usage and b) that high frequency of Facebook checking could be characterized by addictive behavior when future work will be able to extend these findings to more excessive users in the future. The present investigated sample clearly represents rather normal Facebook users
- As a consequence the present study gives insights into the biological underpinnings of daily Facebook usage in a mostly student population and the here proposed connections to addictive behavior need to be considered as preliminary at best.